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THE STATUS OF THE ATLANTIC SALMON STOCK OF HUMBER RIVER/BAY OF ISLANDS, NEWFOUNDLAND, 1994

by

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ABSTRACT

The total recreational catch of retained small salmon on the Humber River in 1994 was below the catch in 1992 and the 1987-1991 and 1953-1991 means. The recreational catch of released large salmon, however, was 10% above the 1992-1993 mean, 249% above the 1987-1991 mean and 95% above the 1953-1991 mean. The results of a creel survey conducted on the Big Falls segment of the Humber River indicated that the total recreational catch of retained small salmon in 1994 was approximately 63% greater than reported in traditional DFO catch statistics. The catch-per-unit-effort of small salmon recorded in the creel survey was less than for 1993 and 1991. The estimated total returns of small salmon to the Humber River in 1994, based on the stratified maximum-likelihood estimate was the lowest of returns since the closure of the commercial salmon fishery in the Bay of Islands but similar to the 1984-1989 mean. The estimate of large salmon returns was the second highest of the last three years and indicates an increase in survival of previously spawned 1SW salmon. The potential egg deposition achieved on the Humber River in 1994 from small and large salmon was below the target requirement for conservation. Lower egg depositions in 1994 relative to 1992 and 1993 are attributed to lower spawning escapement in 1989. On the basis of the relationship between recruits and spawners on the Humber River in 1977-1994 it is anticipated that returns of small and large salmon in 1995 will be above the target spawner requirements.

RÉSUMÉ

Le nombre total de petits saumons de la rivière Humber capturés et gardés par les pêcheurs sportifs en 1994 était inférieur à celui de 1992 et aux moyennes de 1987-1991 et 1953-1991. Toutefois, les prises sportives de grands saumons remises à l'eau étaient supérieures de 10 % à la moyenne de 1992-1993, de 249 % à la moyenne de 1987-1991 et de 95 % à la moyenne de 1953-1991. Les résultats d'une enquête auprès des pêcheurs sportifs qui pratiquent leur activité dans la partie de la rivière Humber située à Big Falls révélaient que les prises sportives totales de petits saumons gardées en 1994 étaient supérieures de 63 % environ aux prises déclarées dans les statistiques traditionnelles du MPO. En ce qui concerne les petits saumons, les prises par unité d'effort estimées d'après l'enquête étaient inférieures à celles de 1993 et de 1991. Les montaisons totales de petits saumons dans la rivière Humber en 1994, fondées sur l'estimation stratifiée du maximum de vraisemblance, étaient les plus basses depuis la fermeture de la pêche commerciale du saumon dans la Bay of Islands et se comparaient à la moyenne de 1984-1989. Toutefois, les estimations de montaisons de grands saumons étaient parmi les plus élevées de celles des trois dernières années, arrivant au deuxième rang, et dénotent une hausse de la survie des saumons unibermarins à pontes multiples. La ponte estimée des grands et des petits saumons dans la rivière Humber en 1994 était inférieure à la cible établie pour la conservation. La diminution de la ponte par rapport à 1992 et 1993 est attribuée à une baisse des échappées de reproducteurs en 1989. En se fondant sur le rapport entre les recrues et les frayeurs dans la rivière Humber de 1977 à 1994, on anticipe que les montaisons de petits et de grands saumons en 1995 seront supérieures au niveau-cible de reproducteurs.

INTRODUCTION

This is the fifth assessment of the Humber River / Bay of Islands area Atlantic salmon resource. This area is one of four river systems within the Gulf of St. Lawrence identified for a pilot study of the River/Zone Management Strategy. The Humber River is the largest river flowing into the Bay of Islands coastal area which is situated in western Newfoundland at the northern limit of Salmon Fishing Area (SFA) 13 (Figure 1). Potential egg depositions from Atlantic salmon on the Humber River in 1990 and 1991 were 40% and 73%, respectively, below target requirements (Chaput and Mullins 1991, 1992) indicating that the abundance of salmon was less than the minimum levels for conservation. Atlantic salmon were exploited commercially in the Bay of Islands area until 1991 but this fishery was closed in 1992 to help rebuild declining stocks. Recreational fisheries in 1992 continued to harvest salmon in 3 of the 4 tributaries within the bay but were limited by the quota on small salmon harvests which was implemented in all SFA 13 rivers. With the commercial fishery closed in 1992 estimated egg depositions were above the target spawning requirement for the first time in seventeen years.

The total drainage area of the tributaries flowing into the Bay of Islands is 8124 km^2, which is 93% of the drainage area of Statistical Area L (Table 1) and 57% of SFA 13 drainage area. The Humber River comprises 95% of the Bay of Islands drainage area and flows into Humber Arm (Figure 1) at latitude 48° 57' N and longitude 57° 53' W. The total length of all the streams in the Humber River is 2450.5 km. Complete obstructions to migrations of anadromous Atlantic salmon within the Humber River system occur at Main Falls (Figure 2) which is 112.6 kilometres from the river mouth and at Junction Brook which was diverted for hydroelectric development in 1925. The diversion of Junction Brook which flowed into the Humber River at Deer Lake, resulted in the loss to the Humber River system of the anadromous salmon production potential of the Grand Lake system (Porter et al. 1974) (see Figure 2). No fish passage facility was provided during the diversion to maintain upstream migration of fish stocks.

Several Atlantic salmon resource conservation measures have been imposed on the commercial and recreational fisheries since 1978 which have impacted on harvests within the Humber River / Bay of Islands area. The major conservation measures have included:

1. 1978 - commercial season shortened to June 1-July 10 from May 15-December 31.
2. 1984 - mandatory release of large salmon ($\geq$63 cm fork length) in recreational fishery.
3. 1987 - recreational season bag limit of 15 small salmon ($<$63 cm fork length).
4. 1990 - 35 t commercial quota in SFA 13 commercial fishery.
5. 1991 - 25 t commercial quota in SFA 13; recreational season bag limit of 10 small salmon.
6. 1992 - five year commercial moratorium; recreational quota of 5,000 small salmon in SFA 13; recreational quota of 100 small salmon for Adies Lake (Figure 2); a catch and released fishery was permitted after the quota was reached; recreational season bag limit of 8 small salmon.
7. 1993 - recreational quota of 5,200 small salmon in SFA 13 (4,160 for June 5-July 31 and 1,040 for Aug.1-Sept.6); daily bag limit of one fish; Cook's Brook was closed for the season.
8. 1994 - recreational season bag limit of 3 small salmon before July 31 and 3 after July 31; daily bag limit of 2 fish; daily catch and release limit of 4 fish.

The assessment of the status of the Humber River/Bay of Islands Atlantic salmon stock is based on the analysis of annual trends in recreational catches and the estimation of spawning escapement. Spawning escapement is estimated using derived exploitation rates in the recreational fishery applied to the total recreational harvests.

The present document provides the recreational catches and effort, and timing data for the Humber River / Bay of Islands for 1994. It follows the initial assessments presented for 1990, 1991, 1992, and 1993 (Chaput and Mullins, 1991; Chaput and Mullins, 1992; Mullins and Chaput, 1993; Mullins and Chaput, 1994 MS) and addresses the following topics:

1) verification by independent creel method, of the recreational catch statistics collected by the Department of Fisheries and Oceans (DFO) for the Big Falls segment of the Humber River,
2) estimation of the exploitation rate by the recreational fishery on small salmon in 1994 by mark-recapture methods,
3) updating of the biological characteristics of the Humber River/Bay of Islands Atlantic salmon stock for 1994,
4) examination of the effect of the 1994 management regulations on the spawning escapement to the Humber River,

MATERIALS AND METHODS

Recreational Fishery Statistics

The DFO catch statistics for the recreational fishery were compiled from river guardian and fisheries officer reports. The traditional methods used for summarizing these data are described in Mullins and Claytor (1989) and Mullins et al. (1989). Catch and effort for the Humber River are described by river segment (Figures 1 & 2) and the standardized weeks used are described in Table 2.

Salmon catches in the recreational fishery are categorized into small and large size groups. The criteria for small and large salmon designation are as follows:

Small (Grilse; 1SW)	-	< 63 cm fork length
Large (MSW)	-	≥ 63 cm fork length

Observed catches have generally accounted for 80% of the total catch reported (Mullins and Claytor 1989).

In 1992 and 1993, weekly salmon angling reports were also completed for the catch and release fishery which was permitted after the SFA 13 zonal quota was reached.

Creel Survey, Big Falls

A creel survey to determine the angling catch at Big Falls, Humber River, was conducted between 19 June and 5 September 1994. The Big Falls segment (Figure 2) was again selected for the survey because it is accessed by anglers from two points and the angling catches from this segment have averaged 38% of the total Humber River catch since 1986.

The 1994 creel survey was designed to enumerate all salmon landed at the Big Falls section of the Humber River. The two main locations used by anglers to exit the fishing area were monitored for a total of 16 hours per day from 0600 hrs to 2200 hrs. The clerks recorded the number of hours fished by each angler, the number of salmon retained and released, and the number of carlin tagged salmon recaptured. Clerks were instructed to maintain records completely independent of those kept by DFO Guardians.

Estimation of Exploitation Rate

Tagging traps were operated in the estuary and at Boom Siding on the Humber River in 1994 (Figure 1). Small and large salmon were marked with individually numbered green Carlin tags and released from the two tagging traps. Tags were applied using a double stainless steel wire attachment, directly under the dorsal fin. All salmon captured in the two trap were measured (fork length 0.1 cm), and scale sampled.

Estuary Trap - This trap has been fished in the same location at Wild Cove, Humber Arm (Fig. 1), since 1990. The trap design and installation in 1994 were identical to the 1990-1992 sampling program (Chaput and Mullins 1991, 1992; Mullins and Chaput, 1993).

Boom Siding Trap - This trap was fished for the first time in 1994 and was located about 10 km upstream from the estuary trap. The Boom Siding trap was a floating design and was operated in about 6 m water depth. The dimensions of the floating trap were 18.3 m length x 4.9 m width x 5.5 m depth and it was constructed of the same type 5.71 cm stretched mesh nylon as the lower trap.

The angling exploitation rate used to estimate the returns of small salmon to the river in 1994 was the number of tags recaptured by anglers, divided by the number of tags available in the population.

A summary of the equations used to calculate angling exploitation rate in 1994 are given in Table 3.

Exploitation Rate (ER) = Tags Recaptured (TR) / Tags Available (TA)

Estimation of Tags Recaptured

The proportion of recaptured tags that were actually returned by anglers in 1994 was estimated on the basis of recaptures reported by the creel survey clerks at Big Falls.

Reporting Rate (RR) = Observed Tags Returned from Big Falls / Observed Tags Recaptured at Big Falls

$$TR = \text{Total Tags Returned} / RR$$

The ratio *(tags/catch at Big Falls):(tags/catch for the rest of the river)* does not give a valid estimate of the reporting rate because creel clerks did not observe 100% of the tags recaptured at Big Falls.

Estimation of Tags Available

The total number of tagged small salmon available to anglers (TA) on the Humber River in 1994 was estimated by adjusting the number of tags applied for tags lost due to tag shedding after release. The tag loss rate (TL) was estimated based on the proportion of 0.009 tags shed per day to recapture derived for Margaree River in 1992 (Chaput et al. 1993). The method of tag application to salmon in the Margaree River tagging program is the same as for the Humber River. Median days to recapture were determined according to (Sokal and Rohlf, 1969). Tags available to anglers was estimated from the number of tags applied to small salmon multiplied by the proportion of tags retained (1- TL).

$$TA = \text{Tags Applied} \times (1 - TL)$$

Where:

Tag-Loss Rate (TL) = (0.009 tags/day x Median Days to Recapture)

Injured fish were not tagged and no tagging was conducted at water temperatures above 20 C. Therefore, tagging mortality is believed to be negilible. All salmon tagged in the estuary trap in 1994 are assumed to be destined for the Humber River, however, some recaptures of tagged bright salmon were reported in the past from Hughes Brook.

Estimation of Total Recreational Harvest

The total recreational catch of small salmon for the Humber River was adjusted based on the catch of small salmon recorded by the creel survey clerks at Big Falls and the proportion of the total angling catch taken at Big Falls.

Adjusted Catch (AC) = Catch at Big Falls (Creel) / Proportion at Big Falls

Two methods were used to estimate the proportion of the total river harvest angled at Big Falls: 1. the proportion of catch reported from Big Falls in the DFO catch statistics and 2. the proportion of tags returned from Big Falls. The average of these two values was used to determine the total catch.

Catches of small salmon recorded by the creel survey clerks at Big Falls were from immediately below (1-2 km) the falls area and did not include the pools further downstream (Mistaken Point area) which were accessed via another route, but which would have been included in the Big Falls area of the DFO catch statistics (Fig. 3). As a result the catch recorded by the creel survey clerks at the falls was adjusted to give a catch for the entire Big Falls area. This was done based on the proportion of tags recaptured at the falls and in the Mistaken Point area. No tags were recaptured in the Big Falls area above the falls.

Returns to the Humber River

The returns of small salmon to the Humber River were estimated by:

1. the Peterson (Single Census) method (Ricker, 1975) according to the formula

Returns of Small (RS) = AC / ER , and

2. a maximum-likelihood stratified design following the method of Dempson and Stansbury (1991) and Darroch (1961). Both estimates were based on the total adjusted catch of small salmon, adjusted tags available to angling, and adjusted recaptures.

For the maximum-likelihood estimate, tag releases and tag recaptures were initially stratified into six intervals. Release intervals were either two or three weeks, but all recapture intervals were two weeks. The original matrix was collapsed to reduce the number of intervals with zero releases or recaptures.

The returns of large salmon were determined by applying the ratio of large to small salmon captured in the two tagging traps to the estimate of small salmon returns where:

Returns of Large (RL) = RS x Ratio of Large:Small at Tagging Traps

In the 1990 and 1991 assessments, the appropriate ratio of large to small salmon returns to the river was considered to be equivalent to the ratio of large to small salmon in the recreational fishery (7%) prior to 1984 when large salmon could be retained (Chaput and Mullins 1991, 1992). However, a commercial fishery was also permitted in these years. Because of the closure of the commercial fishery in 1992 and the potential for an increase in the river escapement of large salmon, the ratio of large to small salmon captured at the tagging traps is considered to be more representative of returns to the river.

Biological Characteristics

Biological characteristics of Humber River salmon in 1994 were obtained from bright salmon at the traps and from angling catches landed at the Big Falls segment of the Humber River. The fish were sampled for fork length (0.1 cm) and whole weight (0.01 kg) and sex determination was by internal examination except on live fish. Scale samples were obtained for determining the river-age and sea-age. These methods were identical to those used in 1990-1993.

Estimation of Target Spawning Requirements

Target egg deposition for the Humber River was calculated using an optimal egg deposition for fluvial and lacustrine parr rearing area. In previous assessments (1990-1992) for the Humber, lacustrine area had not been included in calculating the target egg deposition. However, values of the percentage of the target achieved in those years which are presented in this document have been recalculated based on the adjusted target. The egg deposition rate used for fluvial area was 2.4 eggs/m^2 as described by Porter and Chadwick (1983) and the egg deposition rate used for lacustrine area was 368 eggs/ha as described by O'Connell (1991). The fluvial parr rearing area for the Humber River has been estimated at 11,530,700 m^2 (Porter and Chadwick 1983). The available lacustrine area was measured from 1:50,000 scale topographic maps using a dot grid.

Estimation of Potential Egg Depositions

The potential egg depositions were calculated using the estimated spawning escapement and observed biological characteristics (mean weight of females, percent female, fecundity) of small and large salmon in 1994. The spawning escapement was obtained by subtracting the adjusted total recreational catch of small salmon retained from the estimated returns to the river.

Number of Recruits and Spawners, 1974-94, and Anticipated Returns in 1995

Reddin, et al. (in press) described a technique whereby it was possible to retrospectively construct total population size of small salmon (or total number of small salmon recruits) prior to any exploitation in selected rivers with counting facilities and to use the number of salmon recruits per spawner to estimate anticipated returns one year in advance. The technique is fully described in O'Connell, et al. (in press) and equations used to derive recruits and spawners for the Humber River salmon stock are the same with the exception that large salmon are included (exploitation rate in commercial fishery = 0.80).

Analysis to Detect Recruitment Overfishing

Details on analyses to detect recruitment overfishing are provided by O'Connell, et al. (in press).

RESULTS

Recreational Effort and Catches

The recreational angling season in the Bay of Islands opened on 4 June and closed on 5 September 1994. The Adies Lake quota of 100 small salmon was not reached but this segment closed on 31 July.

The recreational catch of small salmon in the Bay of Islands region in 1994, from DFO catch statistics, was 31.1% below the 1992-1993 mean, 38.5% below the 1987-1991 mean and 46.5% below the 1953-1991 mean (Table 4). The proportion of the SFA 13 catch of small salmon taken in the Bay of Islands in 1994 was about the same as in 1992-1993 and 1987-1991, but 12.4% above the 1953-1991 mean (Table 4). Released catches of large salmon in the Bay of Islands in 1994 were 19.1% above the 1992-1993 mean and 155.6% above the 1987-1991 mean.

Within the Bay of Islands region, recreational catches from the Humber River remained the dominant proportion of the total catch (Table 5). The catch of small salmon on the Humber River in 1994 was 1,550 fish, which was 30.2% below the catch in 1992-1993 and 39.5% below the 1987-1991 mean. Catches of small salmon on Goose Arm River which in 1993 were the highest ever recorded had dropped to 47.4% below the 1992-1993 mean, but were still above the 1987-1991 mean (Table 5).

Released catches of small salmon from the Humber River in 1994, were 23% of the total retained and released catches (Table 6). This was similar to 1993 when released catches were 27% of the total, but more than twice the value in 1992 (8%). Observed effort and catch recorded by the DFO catch statistics were about 30% of the total.

The highest angling effort on the Humber River in 1994 was at Big Falls followed by the Lower Humber (Table 7a). The effort at Big Falls was 10.4% below the 1992-1993 mean, 18.6% above the 1987-1991 mean, but 6.3% below the 1977-1986 mean. The effort on the Lower Humber was 26.3% above the 1992-1993 mean (Table 7a).

The recreational catches of small salmon on six of eight segments of the Humber River were below those in 1993 (Table 7b). Only the Lower Humber and Adies Lake had higher catches than in 1993. Big Falls again produced the highest catches, but these were 45.3% below the 1992-1993 mean, and 31.5% below the 1987-1991 mean. The catch at Big Falls in 1994 represented 42% of the Humber River catch compared to 40% in 1993, 63% in 1992, and an average of 50% in 1976-1991.

The highest released catch of large salmon was on the Lower Humber River which was 88.6% above the catch in 1992-1993 and 371.4% above the 1987-1991 mean (Table 7b).

Creel Survey Catches at Big Falls

A total of 3,839 anglers were interviewed or observed in the creel survey at Big Falls in 1994 (Table 8). Each angler fished for an average of 3.70 hours which was similar to the average effort expended in 1993, but 14.5% less than in 1992 (Table 8). The total catch observed was 765 small salmon retained and 436 released, and 63 large salmon released (Table 8). The catch of small salmon retained per unit of effort (CPUE) for interviewed anglers was the lowest in the three years that the survey was conducted (Table 8).

A total of 14 carlin tagged small salmon were observed by the creel clerks in 1994 (Table 8). Nine of these were subsequently returned voluntarily by anglers for a reporting rate of 0.64 which is similar to the rate of 0.75 which was assumed for the Humber River in 1993.

The distribution of weekly angling effort and catch of small salmon retained were similar for the creel survey and the DFO catch statistics (Table 9; Figs. 4, 5). Week 27 was the peak of angling effort and catch. However, the total catch of small salmon retained observed in the creel survey was 17.5% higher than the catch recorded in the DFO statistics (Table 9), even though the DFO records covered a larger area (Fig. 3).

Estimation of Total Catch

The adjusted total catch of small salmon at Big Falls was 1,011 and the adjusted total catch for the Humber River was 2,523 (Table 10).

Estimation of Exploitation Rate

The Estuary tagging trap was operated from 6 June to 1 September and the Boom Siding Trap operated from 1 June to 29 August 1994. A total of 81 large and 629 small bright salmon were captured in the Estuary and Boom Siding traps (Table 11). The ratio of large:small salmon captured in both traps in 1994 was 0.1288:1 which was more than twice the ratio of large:small salmon in 1992 (Table 12).

The peak catches of small salmon in the estuary occurred in mid-late June (Fig. 6a), whereas, the peak catches at Boom Siding occurred in early July (Fig. 6b). The peak of large salmon catches occurred about mid-June in both traps (Figs. 6a, 6b).

A total of 601 (426 estuary; 175 Boom Siding) small bright salmon and 81 (78 estuary; 3 Boom Siding) large salmon were tagged and released from the two traps (Table 13).

The peak of tag releases from the Boom Siding trap was in week 27 which was two weeks later than in the estuary trap (Fig. 8), and peak recaptures from angling of tags applied at Boom Siding was week 30, also about two weeks later than recaptures of those applied in the estuary trap (Figs. 9).

Tagged small salmon were recaptured by angling in each week of the fishery (Table 13) with the distribution of recaptures corresponding to the distribution angling catches (Fig. 10), indicating that tagged fish were evenly dispersed in the population and available to the fishery at the same time as untagged fish. However, tag recaptures at Big Falls did not correspond to angling catches in the first two weeks of angling (Fig. 11).

Tagging was not carried out at surface water temperatures above 20 C and the number of tags returned did not appear to be related to the water temperature at the time of tagging (Table 14).

Tags recaptures were recorded from all major segments of the Humber River (Table 15). The largest number of recaptures were at Big Falls (37) followed by Harriman's Steady (36). A total of 97 tags were returned from small salmon and 4 from large salmon (Table 16).

Five of the small salmon released from the estuary trap were subsequently recaptured in the Lower Humber River which is downstream from the trap at Boom Siding (Table 15).

The median number of days before recapture for tagged fish was 16.6 days (Table 17). This was similar to the mean number of days at large for tagged salmon in 1993. The minimum was 0 days and the maximum was 80 days. The estimated overall proportion of tags retained was 0.8380 (1-(0.009 x 18 days)).

The minimum angling exploitation rate on Humber River small salmon in 1994, unadjusted for tag loss or tag reporting rate, was 0.1544 (92/596). This value was similar to the unadjusted rates derived for 1990 (0.134), 1991 (0.164), and 1993 (0.1455).

After adjustment for tag loss and reporting rate, the overall adjusted exploitation rate for 1994 was 0.2865 (Table 17). This was higher than the adjusted rates of 0.25 derived for 1990 and 1991, and 0.2213 in 1993. Angling exploitation was highest on salmon tagged and released during week 22-23 and ranged from 0.1731-0.7098 throughout the season, but tended to be lower towards the end of the season (Table 17). The range in exploitation rates derived for each two week period indicates that the fishery harvested certain portions of the returns more than others.

Biological Characteristics

Small salmon captured in the traps in 1994 were primarily virgin one-sea-winter (1SW), whereas, large salmon were primarily repeat spawning 1SW fish. The mean fork length of small, 1SW salmon sampled from the tagging traps in 1994 was 53.58 cm (N=628) and the mean fork length of large, MSW salmon was 74.06 cm (N=82). The mean weight of small, 1SW female salmon sampled in the recreational fishery was 1.70 kg (N=21) and the percentage female was 50.89 (N=112) (Table 18). About 56% of the small, 1SW salmon sampled at the traps and in the recreational fishery were smolt-age-3 and about 42% were smolt-age-4 (Table 18).

Returns and Escapements to the Humber River.

The Peterson (single census) method estimated 7,777 (95% CI = 6,600 - 9,158) small salmon returns in addition to 295 fish angled in the Lower Humber River for a total of 8,072 small and 1,040 large salmon returns in 1994 (Table 19). The maximum-likelihood stratified estimate was 7,700 (95% CI = 6,235 - 9,165) for a total of 7,995 small and 1,030 large salmon (Table 19). The potential spawning escapement was 5,549 small and 1,040 large salmon based on the Peterson estimate, and 5,472 small and 1,030 large based on the stratified estimate. The number of small salmon spawners in 1994 were well below the minimum requirement (Fig.11). Large salmon spawners were also below the target, but were the fourth highest since 1975 (Fig. 12).

The potential spawning escapements for 1994 from the Peterson and stratified estimates would have resulted in potential egg depositions which were 41% and 40%, respectively, of the target spawning requirement (Table 20). Estimates of potential egg deposition from both estimates of returns in 1994 are below the 1992 and 1993 estimates, but the percent of the target achieved based on the stratified estimate of returns in 1994 was 25% below 1984-1991 mean (Table 21).

Atlantic salmon on the Humber River spend an average of three years in the river before migrating to sea (Table 18). In 1994, 56.5% of small salmon captured in the tagging traps had a smolt-age of 3 years, and 42.4% had a smolt-age of 4 years compared to 80% at smolt-age-3 in 1993. Ninety-seven percent of these fish had spent one year at sea before returning to spawn for the first time. Based on the time spent in the river and at sea, the majority of returns to the river in 1994 were the cohorts of spawners in 1988 and 1989. Spawners in 1989 were the lowest in recent years (Fig. 11). Given a similar age composition to 1994, returns of small salmon in 1995 will be the cohorts of spawners in 1989 and 1990. Returns in 1995, similar to 1994, may also be influenced by the low spawning escapement in 1989.

Number of Recruits and Spawners, 1974-94, and Anticipated Returns in 1995

The outcome of calculations of total numbers of salmon recruits, numbers of spawners, and numbers of recruits per spawner are shown in Figs. 13-17. The number of small and large salmon recruits and corresponding number of spawners for each year class are shown in Fig. 13. There was a lot of variability in recruitment from a given spawning escapement. Since 1974, there was a significant decline ($r^2=0.40$; df = 19; $P<0.01$) in the total number of small and large salmon recruits for Humber River (Fig. 14). Except for 1990, the lowest recruitment for the entire time series was experienced during the period 1989-1994. In fact, 1994 is the lowest.

There was no identifiable trend in the total number of small and large spawners (Fig. 14). Expressing target spawning requirement in terms of salmon adults (horizontal line in Fig. 14), it is evident that target spawners were achieved in 1975-1976 and 1992. Numbers of spawners in 1992-94 although declining over that period compare well with higher values in the past, particularly the late 1970s and early 1980s, and represent a substantial improvement over the lows observed for 1989 and 1991.

The total number of salmon recruits produced for each spawners showed no trend for small salmon ($r^2=0.13$; df = 14; $P>0.05$) (Fig. 15) but declined significantly for large salmon ($r^2=0.60$; df = 13; $P<0.01$) (Fig. 16). The number of small and large salmon recruits anticipated for 1995, based on the average number of small and large recruits produced per spawner for each river age grouping, is approximately 17,000 small and large salmon (Fig. 17).

Analysis to Detect Recruitment Overfishing

During the commercial fishery moratorium years 1992-1994, numbers of spawners in Humber River were above the replacement (diagonal) line (Fig. 18). In two of the three years immediately preceding the moratorium, 1989 and 1991, numbers of spawners were well below the replacement line. Of the total number of 15 data points, 8 were below.

DISCUSSION

Recreational catches of small salmon on the Humber River declined in 1994 compared to the 1992-1993 mean, but increased in relation to the rest of SFA 13. This increase in the percentage of SFA 13 catches of small salmon taken in the Humber River/Bay of Islands region may be due to the low returns to the Bay St. George area of SFA 13 as indicated by low angling catches in 1994. Encouragingly, recreational catches of large salmon released in the Humber River/Bay of Islands area were above the 1992-1993 mean and substantially above the previous five years when there was great concern over declining large salmon stocks.

Recreational catch statistics indicated that the abundance of small salmon on the Humber River in 1994 were below 1992 and 1993 levels. The interpretation of the recreational data is confounded by the unknown effect of the changes in the daily bag limit over the last three years and the switch from zonal quotas to the split season in 1994. However, the conclusion of lower abundance of small salmon on the Humber River in 1994 is supported by low catches in other SFA 13 rivers and the lower CPUE in 1994 (0.27) compared to 1993 (0.31) and 1992 (0.36). The CPUE calculated from the creel survey results in 1994 was also lower than similarly derived CPUE in previous years. Similar to 1991, when catches were also low, there was little difference between the DFO and creel survey results in 1994. In contrast, it appears that in 1992 and 1993, when angling catches were higher and the discrepancy between the two estimates of catch at Big Falls was greatest, it was more difficult to obtain accurate catch data by the traditional methods. Based on the creel survey results in 1994, the total recreational catch of small salmon on the Humber River may have been about 63% higher than the estimate provided by DFO catch statistics. If this is true for other rivers then population sizes derived from catch statistics will be underestimated on these rivers.

The high effort on the Lower Humber River in 1994 compared to the 1992-1993 mean was probably due to the increase in catches of large salmon on this section of the river indicating an increase in the abundance of large salmon.

The Darroch (1961) stratified estimate of small salmon returns in 1994 and 95% confidence limits were almost identical to the Peterson estimates. However, there was some variation in recapture probabilities among the three recapture strata of the Darroch (Appendix 2). The mean of the Darroch recapture probabilities (0.2760) was very similar to the Peterson (Table 17). Pooling of several of the initial strata was necessary for the Darroch estimator and probably reduced the differences in recapture probabilities between the three collapsed strata. If the sample size had been large enough to maintain the initial number of strata, the stratified estimate of small salmon returns would have been an even more appropriate estimator than the single census estimate.

The stratified estimate of returns of small salmon to the Humber River in 1994 was 58% below returns in 1993, corresponding to lower spawning escapement in 1989 compared to 1988. However, returns in 1994 were also comprised of a large proportion of the 1988 cohort (river-age-4) which probably resulted in higher returns than would have been the case if the proportion of river-age-4 fish had been similar to 1993. If the survival in the river and at sea of the 1990 cohort is similar to that of the 1988 cohort then the return of small salmon to the Humber River in 1995 is anticipated to be above the 1994 level, and comparable to 1992 and 1993 (Fig. 12).

Large salmon on the Humber River in 1994 were primarily repeat spawning 1SW salmon which spawned for the first time in 1992. Returns of small salmon in 1992, the first year of the closure of the commercial fishery in the Bay of Islands, were the highest of estimates recorded for the Humber River indicating an increase in the sea-survival of previously spawning salmon. Supporting the conclusion of increased large salmon abundance in 1994.

Assuming no removals for recreational fishing, the anticipated spawning escapement for 1995 based on trend analysis will be above target by 40% for small salmon and below target by 37% for large. With removals of small salmon for the angling fishery similar to exploitation patterns in 1994, target spawners would be achieved in terms of small salmon only. The variability in recruitment described in Fig. 12 must be kept in mind with respect to estimates of anticipated returns.

In a stock with a healthy spawning population it is suggested that points in the spawner-recruit relationship described in Fig. 18 should fall above and below the line in a 50:50 distribution. Also, the points should fall above the target spawning line which in the case of the Humber only two years, viz. 1992 and 1993 do. We conclude from this that the Humber River salmon stock while being below target spawning in some years, is now in a position to increase in size.

In order to improve the accuracy of the mark-recapture technique in assessing the impact of the commercial closure on the Humber River Atlantic salmon resource, estimates of recreational catches have to be improved. One way to accomplish this would be to conduct an intensive creel surveys at Big Falls and other sections of the river in order to count all landings and ensure 100% reporting of all tags recaptured. Another improvement would be to obtain a complete count of small and large salmon returns to a portion of the river system using a counting fence or other technology.

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Table 1. Boundaries of Statistical Areas and Statistical Sections of Salmon Fishing Area (SFA) 13 and communities within coastal areas of Bay of Islands.

Statistical Area	Section	Boundary
K	40	Cape Ray to Sandy Point
	41	Sandy Point to Cape St. George
L	42	Cape St. George to Long Point
	43	Long Point to Bluff Head
	44	Bluff Head to Cape St. Gregory

Table 2. Standardized weeks used for summarizing catch and effort data.

Week	Time Period
22	May 28 to June 3
23	June 4 to 10
24	June 11 to 17
25	June 18 to 24
26	June 25 to July 1
27	July 2 to 8
28	July 9 to 15
29	July 16 to 22
30	July 23 to 29
31	July 30 to August 5
32	August 6 to 12
33	August 13 to 19
34	August 20 to 26
35	August 27 to Sept. 2
36	Sept. 3 to 9
37	Sept. 10 to 16
38	Sept. 17 to 23
39	Sept. 24 to 30
40	Oct. 1 to 7

Table 3. Equations used in estimation of angling exploitation rate, total catch and total returns of Atlantic salmon to the Humber River, 1994. Parameters in bold type changed values with each iteration of the simulation procedure.

1. EXPLOITATION RATE	=	Tags Recaptured / Tags Available
Tags Recaptured	=	Tags Returned / Reporting Rate
Reporting Rate	=	**Tags Returned from Big Falls / Tags Recaptured at Big Falls** = 9 / 14 = **0.6429**
Tags Available	=	Tags Applied x Proportion Tags Retained
Proportion Tags Retained	=	**1 - (Tag Loss Rate (TL))** TL = (0.009 tags/day x Median Days to Recapture) Range of Days to Recapture = 2 to 77 days; Median = 16.6
2. CATCH	=	Adjusted Catch at Big Falls / **Proportion of Catch from Big Falls** (Mean proportion of catch from Big Falls, 1984-94 = 0.4007)
Adjusted Catch at Big Falls (Small)	=	Creel Survey Catch from Falls Area / **Proportion of Tags Recaptured from Falls Area** (Proportion tags from Big Falls Area = 28/37 = 0.7568)
3. RETURNS (Small) (Petersen single census)	=	CATCH (Small) / EXPLOITATION RATE
RETURNS (Large)	=	RETURNS (Small) **Ratio Large:Small in Trapnets** (Ratio Large:Small = 81/629 = 0.1288)

The equations were solved 5000 times to generate the distribution from which confidence limits were determined

Table 4. Recreational catches (DFO) of small and large Atlantic salmon from the Bay of Islands area, 1953-1994. Numbers in parentheses and catches of large salmon, 1985-1994 are released fish.

	Small Salmon					Large Salmon				
		Bay of Islands, % of					Bay of Islands, % of			
Year	Bay of Islands	SFA 13	Area L	Section 44		Bay of Islands	SFA 13	Area L	Section 44	
1953	1260	28.0	90.7			149	11.5	64.8		
1954	876	34.1	88.1			137	15.8	69.9		
1955	1391	38.0	90.7			139	17.2	72.0		
1956	1103	23.9	77.7			114	7.9	40.3		
1957	1786	26.3	81.1			91	4.8	31.1		
1958	1687	33.1	87.9			195	9.9	47.6		
1959	1999	41.0	90.6			187	14.3	49.3		
1960	1943	31.9	90.0			179	19.3	55.2		
1961	1884	31.5	92.0			134	10.9	51.5		
1962	2411	25.6	82.0			110	7.5	32.7		
1963	3932	31.1	92.7			162	6.4	54.2		
1964	4832	33.7	89.6			273	10.8	42.0		
1965	4071	38.7	92.8			193	10.0	50.1		
1966	4118	51.0	93.0			322	17.1	74.4		
1967	2344	28.9	93.7			160	8.7	59.9		
1968	2477	29.6	90.1			96	8.4	59.3		
1969	4960	40.8	96.1			485	29.9	89.5		
1970	3445	35.4	96.1			553	33.7	93.1		
1971	4041	42.4	96.6			375	35.9	97.4		
1972	4065	48.4	97.2			221	20.0	95.3		
1973	3726	36.3	97.1	97.5		328	23.6	88.2	88.9	
1974	2745	38.2	95.7	97.5		107	11.7	62.2	85.6	
1975	6153	51.3	98.7	98.9		114	12.9	87.7	94.2	
1976	5129	49.4	97.5	97.5		65	10.4	90.3	90.3	
1977	2238	33.3	95.0	95.0		45	4.3	81.8	81.8	
1978	2725	51.5	92.0	92.0		187	21.9	72.5	72.5	
1979	3361	55.9	97.8	97.8		27	23.9	93.1	93.1	
1980	3531	44.6	95.4	95.4		305	30.7	95.3	95.3	
1981	4148	44.6	94.5	95.9		153	23.1	93.9	95.0	
1982	4313	45.1	95.4	96.3		96	16.1	76.2	81.4	
1983	3152	49.7	96.6	97.5		47	7.7	83.9	90.4	
1984	2872	37.0	98.2	98.8		40	12.9	85.1	87.0	
1985	2430	45.8	100.0	100.0		11	4.3	100.0	100.0	
1986	3456	47.0	98.0	100.0		261	37.8	100.0	100.0	
1987	3093	51.4	96.3	97.5		113	33.0	89.7	89.7	
1988	4093	49.8	93.4	95.6		144	35.5	81.8	91.7	
1989	1312	41.3	90.0	92.5		11	8.4	42.3	42.3	
1990	3106	46.4	93.5	96.0		75	22.5	84.3	85.2	
1991	1535	29.6	89.1	92.1		11	5.4	19.3	19.3	
1992	2261	41.6	90.8	90.8		178	18.8	64.7	66.7	
1993	2426	47.6	92.3	94.2		126	17.2	60.6	64.6	
1994	1615	44.4	90.4	93.3		181	19.5	64.2	66.1	
Mean										
1992-1993	2344	44.6	91.6	92.5		152	18.0	62.7	65.6	
1987-1991	2628	43.7	92.5	94.7		71	21.0	63.5	65.6	
1953-1991	3019	39.5	92.9	96.5		164	16.6	70.7	83.4	
% Change in 1994 from:										
1992-1993	-31.1	-0.3	-1.3	0.9		19.1	8.2	2.4	0.6	
1987-1991	-38.5	1.7	-2.2	-1.5		155.6	-7.1	1.1	0.6	
1953-1991	-46.5	12.4	-2.7	-3.3		10.0	17.7	-9.2	-20.7	

Data Sources: 1953 to 1986, Mullins et al. (1989).
1987 to 1988, Mullins and Claytor (1989).
1989, Claytor and Mullins (1990).

Table 5. Recreational catches (DFO) of small and large Atlantic salmon from Bay of Islands rivers, 1953-1994. Numbers in parentheses and catches of large salmon, 1985-1994 are released fish.

	Small Salmon					Large Salmon				
Year	Humber River	Hughes Brook	Cooks Brook	Goose Arm	Humber % of Bay of Islands	Humber River	Hughes Brook	Cooks Brook	Goose Arm	Humber % of Bay of Islands
1953	1260	0	0		100.0	149	0	0		100.0
1954	876	0	0		100.0	137	0	0		100.0
1955	1376	0	0	15	98.9	138	0	0	1	99.3
1956	1076	0	0	27	97.6	110	0	0	4	96.5
1957	1778	0	0	8	99.6	89	0	0	2	97.8
1958	1686	0	0	1	99.9	194	0	0	1	99.5
1959	1996	0	0	3	99.8	187	0	0	0	100.0
1960	1938	0	0	5	99.7	178	0	0	1	99.4
1961	1867	0	0	17	99.1	134	0	0	0	100.0
1962	2390	0	0	21	99.1	108	0	0	2	98.2
1963	3898	0	0	34	99.1	160	0	0	2	98.8
1964	4681	0	125	26	96.9	268	0	3	2	98.2
1965	3951	0	98	22	97.1	193	0	0	0	100.0
1966	3989	0	43	86	96.9	322	0	0	0	100.0
1967	2252	0	71	21	96.1	160	0	0	0	100.0
1968	2168	57	236	16	87.5	96	0	0	0	100.0
1969	4459	74	416	11	89.9	478	7	0	0	98.6
1970	2785	211	423	26	80.8	526	27	0	0	95.1
1971	3949	44	48	.	97.7	375	0	0	.	100.0
1972	3961	55	47	2	97.4	219	0	1	1	99.1
1973	3411	177	133	5	91.5	304	24	0	0	92.7
1974	2742	.	2	1	99.9	107	0	0	0	100.0
1975	6147	4	2	0	99.9	114	0	0	0	100.0
1976	5102	6	0	21	99.5	61	0	0	4	93.8
1977	2158	64	4	12	96.4	45	0	0	0	100.0
1978	2722	.	0	3	99.9	187	.	0	0	100.0
1979	3343	.	0	18	99.5	27	.	0	0	100.0
1980	3512	.	0	19	99.5	303	.	0	2	99.3
1981	4132	.	0	16	99.6	153	.	0	0	100.0
1982	4287	.	0	26	99.4	95	.	0	1	99.0
1983	3110	.	0	42	98.7	47	.	0	0	100.0
1984	2872	.	0	.	100.0	40	.	0	.	100.0
1985	2430	.	0	.	100.0	11	.	0	.	100.0
1986	3456	.	0	.	100.0	261	.	0	.	100.0
1987	3074	.	4	15	99.4	113	.	0	0	100.0
1988	4042	.	16	35	98.8	144	.	0	0	100.0
1989	1217	.	33	62	92.8	10	.	1	0	90.9
1990	3054	.	17	35	98.3	75	.	0	0	100.0
1991	1431	.	12	92	93.2	11	.	0	0	100.0
1992	2234 (194)	.	(3)	27 (17)	98.8	177	.	0	1	100.0
1993	2206 (601)	.	.	220 (2)	90.9	125	.	.	1	100.0
1994	1550 (463)	.	.	65 (6)	96.0	166	.	.	15	91.7
Mean										
1992-1993	2220	.	.	124	94.9	151	0	0	1	100.0
1987-1991	2564	.	16	48	96.5	71	0	0	0	98.2
1953-1991	2938	.	44	20	97.4	162	1	0	1	98.9
% Change in 1994 from:										
1992-1993	-30.2	.	.	-47.4	1.2	9.9	.	.	.	1.9
1987-1991	-39.5	.	.	36.0	-0.5	135.1	.	.	60.9	1.1
1953-1991	-47.2	.	.	223.7	-1.5	2.3	.	.		

Data Sources: 1953 to 1986, Mullins et al. (1989).
1987 to 1988, Mullins and Claytor (1989).
1989, Claytor and Mullins (1990)

Table 6. Weekly observed and estimated recreational catches and effort (DFO) of Atlantic salmon on the Humber River, 1994.

Standardized Week	Effort (Rod-days)			Small Salmon							Large Salmon		
				Retained			Released			Total	Released		
	Obs.	Est.	Total	Obs.	Est.	Total	Obs.	Est.	Total	Small	Obs.	Est.	Total
23	7	10	17	2	2	4	0	0	0	4	0	0	0
24	0	13	13	0	4	4	0	0	0	4	0	0	0
25	16	113	129	2	29	31	2	6	8	39	0	10	10
26	166	366	532	51	121	172	25	60	85	257	7	21	28
27	173	739	912	50	234	284	28	75	103	387	5	19	24
28	439	280	719	127	123	250	56	35	91	341	7	12	19
29	67	539	606	30	175	205	8	59	67	272	0	14	14
30	130	588	718	37	194	231	9	52	61	292	0	11	11
31	223	249	472	70	65	135	10	12	22	157	1	13	14
32	237	329	566	29	56	85	5	6	11	96	5	18	23
33	139	289	428	29	43	72	0	6	6	78	2	11	13
34	194	123	317	27	13	40	0	1	1	41	0	3	3
35	79	72	151	9	18	27	0	4	4	31	0	5	5
36	89	18	107	5	5	10	0	4	4	14	0	2	2
Total	1959	3728	5687	468	1082	1550	143	320	463	2013	27	139	166
Proportion of Total	0.34	0.66		0.30	0.70		0.31	0.69			0.16	0.84	

Table 7a. Angling effort (rod-days) on sections of the Humber River, 1976 -1994. River sections are shown in Figures 1 and 2.

	Effort (rod-days) by location on Humber River								
Year	Humber River Total	Lower Humber	Deer Lake	Harrim. Steady	Little Falls	Big Falls	Adies Stream	Adies Lake	Taylor Brook
1976	10489	1415	430	1454	1620	4076	369	1125	
1977	6127	1243	494	288	778	2445	316	407	156
1978	7633	1312	883	503	1036	2390	491	598	420
1979	7961	1540	737	1010	891	2696	441	274	372
1980	8292	941	879	761	1365	3310	515	338	183
1981	8701	1355	701	708	914	3718	602	447	256
1982	8737	1240	206	816	1476	4194	318	370	117
1983	7746	1762	1224	803	945	1746	387	539	340
1984	7189	1359	322	1281	1174	2412	377	6	258
1985	7211	1196	570	282	1079	2807	479	798	
1986	8635	1814	586	465	1082	2634	484	1570	
1987	7250	1764	482	1005	804	2377	129	641	48
1988	8521	1247	144	923	1769	2894	512	630	402
1989	6014	749	434	713	783	1543	1200	220	372
1990	7008	805	193	1319	980	2377	300	843	191
1991	5770	1038	465	922	357	2014	411	63	500
1992	6072	1237	414	1034	360	2698	115	114	100
1993	7023	976	249	1210	936	2657	501	104	390
1994	5687	1398	118	559	745	2398	211	71	187
Mean									
1992-1993	6548	1107	332	1122	648	2678	308	109	245
1987-1991	6913	1121	344	976	939	2241	510	479	303
1977-1986	7823	1376	660	692	1074	2835	441	535	210
% Change in 1994 from:									
1992-1993	-13.1	26.3	-64.4	-50.2	15.0	-10.4	-31.5	-34.9	-23.7
1987-1991	1.6	-12.9	-27.5	23.9	-0.3	18.6	-1.8	-78.3	28.9
1977-1986	-10.2	-29.1	-62.3	74.9	-12.8	-6.3	13.6	-80.5	85.5

Table 7b. Small salmon retained from sections of the Humber River, 1976 -1994.
River sections are shown in Figures 1 and 2.

		Small salmon (number) by location on Humber River							
Year	Humber River Total	Lower Humber	Deer Lake	Harrim. Steady	Little Falls	Big Falls	Adies Stream	Adies Lake	Taylor' Brook
1976	5102	433	298	689	730	1891	343	718	
1977	2158	229	82	118	359	1207	98	37	28
1978	2722	138	214	210	600	1071	171	198	120
1979	3343	641	275	415	317	1200	191	158	146
1980	3512	195	158	358	712	1817	171	63	38
1981	4132	250	260	327	368	2226	375	242	84
1982	4287	107	53	390	677	2767	154	98	41
1983	3110	218	571	401	409	726	177	446	162
1984	2872	170	101	532	633	1069	210	3	154
1985	2430	38	319	69	382	989	210	423	
1986	3456	238	239	144	496	1367	189	783	
1987	3074	218	209	673	313	1234	50	355	22
1988	4042	225	57	502	929	1563	228	369	169
1989	1214	31	189	187	181	316	195	57	58
1990	3054	148	44	763	372	1138	107	434	48
1991	1431	138	179	364	83	504	95	7	61
1992	2234	61	126	354	166	1497	1	26	3
1993	2206	120	62	469	426	882	130	14	103
1994	1550	181	23	208	289	651	92	37	69
Mean									
1992-1993	2220	91	94	412	296	1190	66	20	53
1987-1991	2563	152	136	498	376	951	135	244	72
1977-1986	3202	222	227	296	495	1444	195	245	77
% Change in 1994 from:									
1992-1993	-30.2	100.0	-75.5	-49.5	-2.4	-45.3	40.5	85.0	30.2
1987-1991	-39.5	19.1	-83.0	-58.2	-23.1	-31.5	-31.9	-84.9	-3.6
1977-1986	-51.6	-18.6	-89.9	-29.8	-41.7	-54.9	-52.7	-84.9	-10.7

Table 7c. Large salmon catches from sections of the Humber River, 1976 -1994.
River sections are shown in Figures 1 and 2.

		Large salmon (number) by location on Humber River							
Year	Humber River Total	Lower Humber	Deer Lake	Harrim. Steady	Little Falls	Big Falls	Adies Stream	Adies Lake	Taylor' Brook
1976	61	18	0	10	5	14	4	10	
1977	45	10	1	0	6	26	2	0	0
1978	187	6	19	2	32	111	16	1	0
1979	27	10	0	4	0	13	0	0	0
1980	303	19	4	4	99	157	10	10	0
1981	153	61	2	1	6	78	4	1	0
1982	95	32	1	3	4	53	2	0	0
1983	47	13	1	1	4	24	1	2	1
1984	40	2	0	6	5	27	0	0	0
1985	0	0	0	0	0	0	0	0	
1986	0	0	0	0	0	0	0	0	
1987	0	0	0	0	0	0	0	0	0
1988	144	4	0	0	30	86	16	0	8
1989	8	1	0	0	0	7	0	0	0
1990	75	54	0	0	7	14	0	0	0
1991	11	11	0	0	0	0	0	0	0
1992	177	22	0	17	14	113	7	3	17
1993	125	48	0	0	15	42	12	2	6
1994	166	66	0	11	31	51	4	3	0
Mean									
1992-1993	151	35	0	9	15	78	10	3	12
1987-1991	48	14	0	0	7	21	3	0	2
1977-1986	90	15	3	2	16	49	4	1	0
% Change in 1994 from:									
1992-1993	9.9	88.6		29.4	113.8	-34.2	-57.9	20.0	-100.0
1987-1991	248.7	371.4			318.9	138.3	25.0		-100.0
1977-1986	85.1	331.4	-100.0	423.8	98.7	4.3	14.3	114.3	-100.0

Table 8. Summary of Big Falls creel survey observations, 1994.

Angling Week	Number Anglers Interviewed	Effort (hours)	Mean Effort per Angler (hours)	Number Small Salmon			Number Large Salmon Released	Number Carlin Tags Observed
				Retained	CPUE	Released		
25	173	430	2.5	20	0.05	15	9	0
26	827	2736	3.3	205	0.07	150	34	3
27	897	3548	4.0	218	0.06	133	15	6
28	481	2208	4.6	125	0.06	71	1	1
29	355	1507	4.2	96	0.06	44	1	2
30	329	1207	3.7	49	0.04	15	1	2
31	330	1148	3.5	25	0.02	5	1	0
32	234	816	3.5	20	0.02	1	0	0
33	119	370	3.1	3	0.01	0	1	0
34	65	169	2.6	1	0.01	2	0	0
35	24	63	2.6	1	0.02	0	0	0
36	5	16	3.1	2	0.13	0	0	
Total	3839	14219	3.7	765	0.05	436	63	14
1993 Values	1613	6031	3.7	412	0.07	30	20	2
1992 Values*	607	2628	4.3	738	0.28	59	25	5
1991 Values	726	1600	2.2	136	0.09			

* Only anglers with catch interviewed in 1992

Table 9. Angling effort and catch of small salmon retained and large salmon released from DFO and Creel methods at Big Falls, 1994.

Angling Week	Effort		Small Salmon Retained		Small Salmon Released		Large Salmon Released		Big Falls Tag Recaptures		
	DFO (rod days)	Creel (hours)	DFO	Creel	DFO	Creel	DFO	Creel	Mistaken Point	Fall	Total Recaptures
25	86	430	24	20	3	15	5	9		1	1
26	369	2736	110	205	33	150	16	34	1	9	10
27	602	3548	159	218	49	133	10	15		7	7
28	463	2208	135	125	36	71	9	1	1	2	3
29	281	1507	88	96	22	44	6	1	1	4	5
30	297	1207	77	49	26	15	4	1	1	3	4
31	115	1148	25	25	3	5	1	1	2	0	2
32	85	816	13	20	1	1	0	0		2	2
33	55	370	10	3	0	0	0	1	1	0	1
34	28	169	6	1	0	2	0	0		0	0
35	14	63	4	1	0	0	0	0	2	0	2
36	3	16	0	2	0	0	0	0			
Total	2398	14219	651	765	173	436	51	63	9	28	37

Table 10. Estimation of total catch of small Atlantic salmon on the Humber River, 1994. Numbers in parentheses are estimated 95% confidence limits.

$$\text{CATCH (Small)} = \frac{\text{Adjusted Catch at Big Falls}}{\text{Proportion of Total Catch taken at Big Falls}}$$

$$\text{Adjusted Catch at Big Falls} = \frac{\text{Creel Survey catch from Falls Area}}{\text{Proportion of Catch from Falls Area}}$$

Area	Tags	Prop. Tags	Creel Catch
Mistaken Point	9	0.2432	
Falls	28	0.7568	765
Total	37	1.0000	

$$= \frac{765}{0.7568}$$

$$= 1,011 \quad (884 - 1,179)$$

$$\text{Proportion of Catch from Big Fall (Tags Method)} = \frac{\text{Tags Returned from Big Falls}}{\text{Total Tag Returns}} = \frac{37}{97} = 0.3814$$

$$\text{(Catch Method)} = \frac{\text{Catch at Big Falls (DFO)}}{\text{Total Catch (DFO)}} = \frac{651}{1,550} = 0.4200$$

(Mean Prop. Catch at Big Falls, 1984-94 = 0.4007)

Summary:

$$\text{CATCH (Small)} = \frac{1011}{0.4007}$$

$$= 2,523 \quad (2,207 - 2,942)$$

Table 11. Sea-age of Atlantic salmon captured in the Estuary and Boom Siding tagging traps on the Humber River, 1994.

	Large salmon (>=63 cm)									Small salmon (<63 cm)					
	Kelts			Brights						Kelts	Brights				
Release Week	1SW	MSW		1SW	MSW	ISW AS	ISW CS	MSW CS	Total	1SW	1SW	MSW	ISW CS	Total	TOTAL BRIGHT
Estuary															
23			1	1	4	14			19	19	6			6	25
24		1	1		7	14	1		22	20	38		1	39	61
25	1	2			7	8			15	24	146	1	1	148	163
26				1	2	4			7		53			53	60
27				1	2	1			4		86			86	90
28				1			1		2		43		4	47	49
29									0		24		4	28	28
30				1			3		4		11		4	15	19
31				2	1		1		4		9		1	10	14
32									0					0	0
33								1	1		5			5	6
34									0		3			3	3
Total	1	3	2	7	23	41	6	1	78	63	424	1	15	440	518
Boom Siding															
22						1			1	10	1			1	2
23									0	5			2	2	2
24						2			2	14	6			6	8
25									0		1			1	1
26									0		56			56	56
27									0		78			78	78
28									0		28			28	28
29									0	1	12			12	12
30									0		2			2	2
31									0		2			2	2
32									0		1			1	1
Total	0	0	0	0	0	3	0	0	3	30	187	0	2	189	192
TOTAL	1	3	2	7	23	44	6	1	81	93	611	1	17	629	710

Table 12. Ratio of large:small bright Atlantic salmon captured In the Humber River tagging traps, 1990-1994.

Year	Large	Small	Ratio Large: Small
1990	18	242	0.0744
1991	3	94	0.0319
1992	30	179	0.1676
1993*	32	910	0.0352
1994*	81	629	0.1288

* Estuary and Boom Siding tagging traps combined.

Table 13. Number of small salmon tagged at two trap locations on the Humber River and recaptures by anglers, 1994.

Release Location	Tagging Week	Number Small Tagged	Recapture Week													Number Recaps.
			.	25	26	27	28	29	30	31	32	33	34	35	36	
Estuary Trap	22	0														0
	23	6														0
	24	38		1	2	2	2									7
	25	143	1		8	9	6			1					2	27
	26	53				3	2	1	2	1		3				12
	27	82					6	4	4		2	1	1			18
	28	44					1		2			1				4
	29	28								1	1	1				3
	30	14								1	1	1				3
	31	10								1			1			2
	32	5														0
	33	3													1	0
	34	0														1
	35	0														0
	36	0														0
	Sub-Total	426	1	1	10	14	17	5	8	5	4	7	2	0	3	77
Boom Siding Trap	22	1														0
	23	2								1			1			2
	24	6														0
	25	1														0
	26	52					2	2	2							6
	27	75					2		1	3		1	1			8
	28	24							1	1	1					3
	29	10								1						1
	30	2														0
	31	1														0
	32	1														0
	33	0														0
	34	0														0
	35	0														0
	36	0														0
	Sub-Total	175	0	0	0	0	4	2	4	5	2	1	0	2	0	0	20
	Total	601	1	1	10	18	19	9	13	7	5	7	4	0	3		97

Table 14. Mean daily water temperature (C) recorded at tagging traps on the Humber River, 1994.

Water Temperature Class (C)	Estuary Trap				Boom Siding Trap			
	Mean Temperature	Release	Recap.	Prop. Recap.	Mean Temperature	Release	Recap.	Prop. Recap.
.	.	86	17	0.20	.	9	2	0.22
5.0-9.9	7.4	258	49	0.19	7.8	134	16	0.12
10.0-14.9	12.3	75	11	0.15	12.8	31	2	0.06
15.0-19.9	15.9	7	0	0.00	15.6	1	0	0.00
20.0-up	.	0	0	.	.			.
Total	12	426	77	0.18	12.1	175	20	0.11

Table 15. Angling recaptures of tagged small Atlantic salmon on sections of the Humber River, 1994.

| Release | Recapture Location and Week | | |

Table 16. Angling recaptures of tagged large Atlantic salmon on sections of the Humber River, 1994.

Release Location	Release Week	Large Tagged Released	Recapture Location and Week: Humber River 27	Big Falls 29	Big Falls 30	Big Falls 31	Big Falls 32	Big Falls 33	Ables Stream 31	Total Tags Returned
Estuary Trap	23	19		1					1	1
	24	22								0
	25	15								0
	26	7								1
	27	4	1					1		1
	28	2								0
	29	0								0
	30	4								0
	31	4								0
	32	0								0
	33	1								0
	Total	78	1	1	0	0	0	1	1	4
Boom	22	1								0
Siding	23	0								0
Trap	24	2								0
	Total	3	0	0	0	0	0	0	0	0
	TOTAL	81	1	1	0	0	0	1	1	4

Table 17. Estimation by two week period of angling exploitation rate based on tags available from the Estuary and Boom Siding tagging traps in 1994. Adjustments are made for tag loss and reporting rate.

Release Period	No. Small Tagged* (X1)	Median Day to Recapture (X2)	Proportio of Tag Retained (X3=1-(X2*0.009))	Adjusted Tags Available (X4=X1*X3)	Tags Returned (X5)	Reporting Rate (X6)	Adjusted Tags Recaptured (X7=X5/X6)	Adjusted Anglin ER (X8=X7/X4)
22-23	9	57	0.487	4	2	0.6429	3	0.7098
24-25	186	14	0.874	163	32	0.6429	50	0.3062
26-27	261	18	0.838	219	43	0.6429	67	0.3058
28-29	105	15	0.870	91	10	0.6429	16	0.1704
30-31	26	9	0.919	24	4	0.6429	6	0.2604
32-34	9	14	0.874	8	1	0.6429	2	0.1977
Overall	596	16.6	0.850	507	92	0.6429	143	0.2824

* No adjustment is made for tagged salmon not destined for the Humber River.
** Five tags recaptured on between the two trapnets (on the lower Humber) are not included in the the analysis.

Table 18. Biocharacteristics of Atlantic salmon on the Humber River, 1994. Smolt age is for males and females.

Angled Salmon

	Smolt Age	Fork Length females (cm)					Whole Weight Females (kg)					No. Percent Female			Smolt Age		
	Group	N	Mean	Min	Max	Std	N	Mean	Min	Max	Std	Sexed	N	%	N	%	Mean
Large	3	0					0					0			2	66.7	
	4	0					0					0			1	33.3	
	Total	0					0					0			3	100.0	3.33
Small	2	2	52.75	51.50	54.00	1.77	1	1.40	1.40	1.40	.	2	2	100.00	4	1.2	
	3	22	53.93	50.00	57.20	2.01	6	1.58	1.32	1.81	0.17	56	22	39.29	185	55.7	
	4	32	55.84	50.00	62.00	3.38	13	1.76	1.32	2.35	0.32	53	32	60.38	142	42.8	
	5	1	56.00	56.00	56.00	.	1	1.91	1.91	1.91	.	1	1	100.00	1	0.3	
	Total	57	55.00	50.00	62.00	2.99	21	1.70	1.32	2.35	0.28	112	57	50.89	332	100.0	3.42
All		57	55.00	50.00	62.00	2.99	21	1.70	1.32	2.35	0.28	112	57	50.89	335	100.0	3.42

DFO Tagging Traps

	Smolt Age	Fork Length females (cm)					Whole Weight Females (kg)					No. Percent Female			Smolt Age		
	Group	N	Mean	Min	Max	Std	N	Mean	Min	Max	Std	Sexed	N	%	N	%	Mean
Large	2	0					0					0			1	1.3	
	3	0					0					0			45	57	
	4	0					0					0			33	41.8	
	Total	0					0					0			79	100	3.41
Small	2	0	.	.	.	.	0	.	.	.	.	0			5	0.8	
	3	3	52.80	51.50	54.30	1.41	3	2.17	2.00	2.30	0.15	6	3	50.00	353	56.8	
	4	1	53.50	53.50	53.50	.	1	1.50	1.50	1.50	.	3	1	33.33	262	42.1	
	5	0	.	.	.	.	0	.	.	.	.	0	0	.	2	0.3	
	Total	4	52.98	51.50	54.30	1.20	4	2.00	1.50	2.30	0.36	9	4	44.44	622	100.0	3.42
All		4	52.98	51.50	54.30	1.20	4	2.00	1.50	2.30	0.36	9	4	44.44	701	100.0	3.42

Table 19. Estimation of Atlantic salmon returns and spawning escapement on the Humber River, 1994.
Numbers in parentheses are estimated 95% confidence limits.

	Parameter Value	
ESTIMATED PARAMETERS:		
Tags Recaptured*	143	(107 - 214)
Tags Available**	507	(478 - 529)
Exploitation Rate	0.2824	
Ratio Large:Small	0.1288	(.1038 - .1547)
CATCH (Small)	2,523	(2,207 - 2,942)
Number Small Retained on Lower Humber	295	
Adjusted CATCH (Small)	2,228	

ESTIMATED RETURNS:

1. (Petersen - single census)
(Based on CATCH (Small) less Lower Humber)

RETURNS (Small) less Lower Humber	7,890	
Number Small Retained on Lower Humber	295	
RETURNS (Small)	8,185	(5,308 - 11,319)
RETURNS (Large)	1,054	(646 - 1,532)
TOTAL (Small+Large)	9,239	
Potential Spawning Escapement:		
Small	5,662	
Large	1,054	
TOTAL	6,716	

2. (Darroch - stratified estimate)

RETURNS (Small) less Lower Humber	7,700	(S.E. =747.61)
Number Small Retained on Lower Humber	295	
RETURNS (Small)	7,995	
RETURNS (Large)	1,030	
TOTAL (Small+Large)	9,025	
Potential Spawning Escapement:		
Small	5,472	
Large	1,030	
TOTAL	6,502	

* Adjusted for mean reporting rate of 0.64.
** Adjusted for tag loss based on 0.009 tags/day.

Table 20. Estimation of Atlantic salmon egg deposition and percentage conservation requirement achieved in the Humber River, 1994. All parameter values are from Porter and Chadwick (1983) except where noted.

HUMBER RIVER

Rearing Units - (100 sq. m)		115,307	
Lacustrine Area (ha)		1,751 (Mullins and Chaput, MS 1994)	
Optimum Egg Deposition		240 eggs per Rearing Unit 368 eggs per hectare of Lacustrine Area	
Biological Characteristics, 1994:			
Fecundity		1,540 eggs / kg	
Small - (<63 cm)	% overall	88.5	(trapnet, 1994)
	% female	50.89 (n=87)	(recreational, 1994)
	mean wt females	1.7 kg (n=21)	(recreational, 1994)
Large - (>=63 cm)	% overall	11.5	(trapnet, 1994)
	% female	68.6	(commercial, 1991)
	mean wt females	3.7 +kg	

Percent Target Eggs Achieved, 1994:

= potential egg depositions / minimum conservation requirement X 100

$$= \frac{\text{small spawners} * (\text{eggs per small spawner}) + \text{large spawners} * (\text{eggs per large spawner})}{(\text{Rearing Units} * 240 \text{ eggs / unit}) + (\text{Lacustrine Area} * 368 \text{ eggs / ha})} \times 100$$

Where:

Eggs per Small Spawner = (.5089 * 1.7 * 1,540)
= 1,332

Eggs per Large Spawner = (.686 * 3.7 * 1,540)
= 3,909

$$= \frac{(\text{small spawners} * 1301) + (\text{large spawners} * 3909)}{28{,}318{,}048} \times 100$$

Where:

		Petersen (single census)	Darroch (stratified)
Small Spawners	=	5662	5472
Large Spawners	=	1054	1030
Total	=	6716	6502
=		41%	40%

Table 21 Summary of Atlantic salmon spawning escapement and percent of conservation requirements met on the Humber River, 1974-1994

STOCK: Humber River, SFA 13

MINIMUM REQUIREMENT FOR CONSERVATION* 28.3 million eggs (13,651 Small and 1,326 Large salmon)

(Minimum Spawner Requirements)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total Angling Catch:																					
Small	2742	6447	5102	2158	2722	3343	3512	4132	4287	3189	2872	2430	3456	3074	4042	1217	3054	1431	4349	4161	2523
Large	107	114	61	45	187	27	303	153	95	47	40	11	261	113	144	10	75	11	177	125	166
Estimated Total Returns:**																					
Small	10968	24588	20408	8632	10888	13372	14048	16528	17148	12440	11488	9720	13824	12296	16168	4868	12216	5724	17571	18477	7995
Large	768	1721	1429	604	762	936	983	1157	1200	871	804	680	968	861	1132	341	855	401	2945	636	1030
Total	11736	26309	21837	9236	11650	14308	15031	17685	18348	13311	12292	10400	14792	13157	17300	5209	13071	6125	20516	19113	9025
Estimated Spawning Escapement:																					
Small	8226	18441	15306	6474	8166	10029	10536	12396	12861	9330	8616	7290	10368	9222	12126	3651	9162	4293	13222	14316	5472
Large	661	1607	1368	559	575	909	680	1004	1105	824	764	680	968	861	1132	341	855	401	2945	636	1030
Total	8887	20048	16674	7033	8741	10938	11216	13400	13966	10154	9380	7970	11336	10083	13258	3992	10017	4694	16167	14952	6502
%of Minimum Conservation Requirement Met (Small + Large)*:**																					
	52	119	100	42	50	66	64	79	83	61	56	48	68	61	80	24	60	27	117	96	40

* The minimum egg deposition requirement has been adjusted from previous reports to reflect total available rearing habitat including the available lacustrine area.

** Total returns for 1974-1991 were estimated based on an angling exploitation rate of 25% adjusted for tag loss and reporting rate (Chaput and Mullins, 1990)

*** 1974-1990 is based on biological characteristics from Porter and Chadwick, 1983

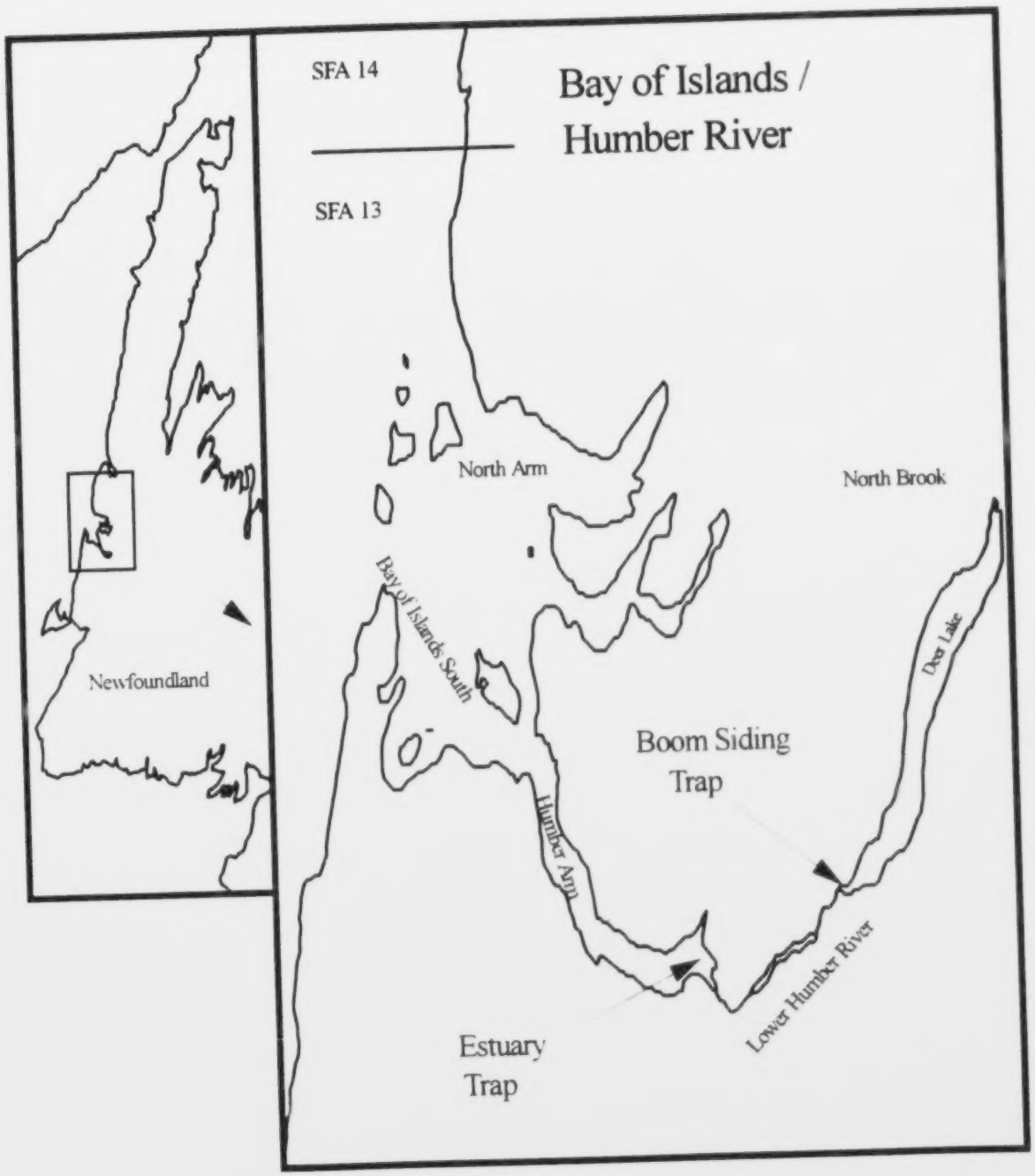
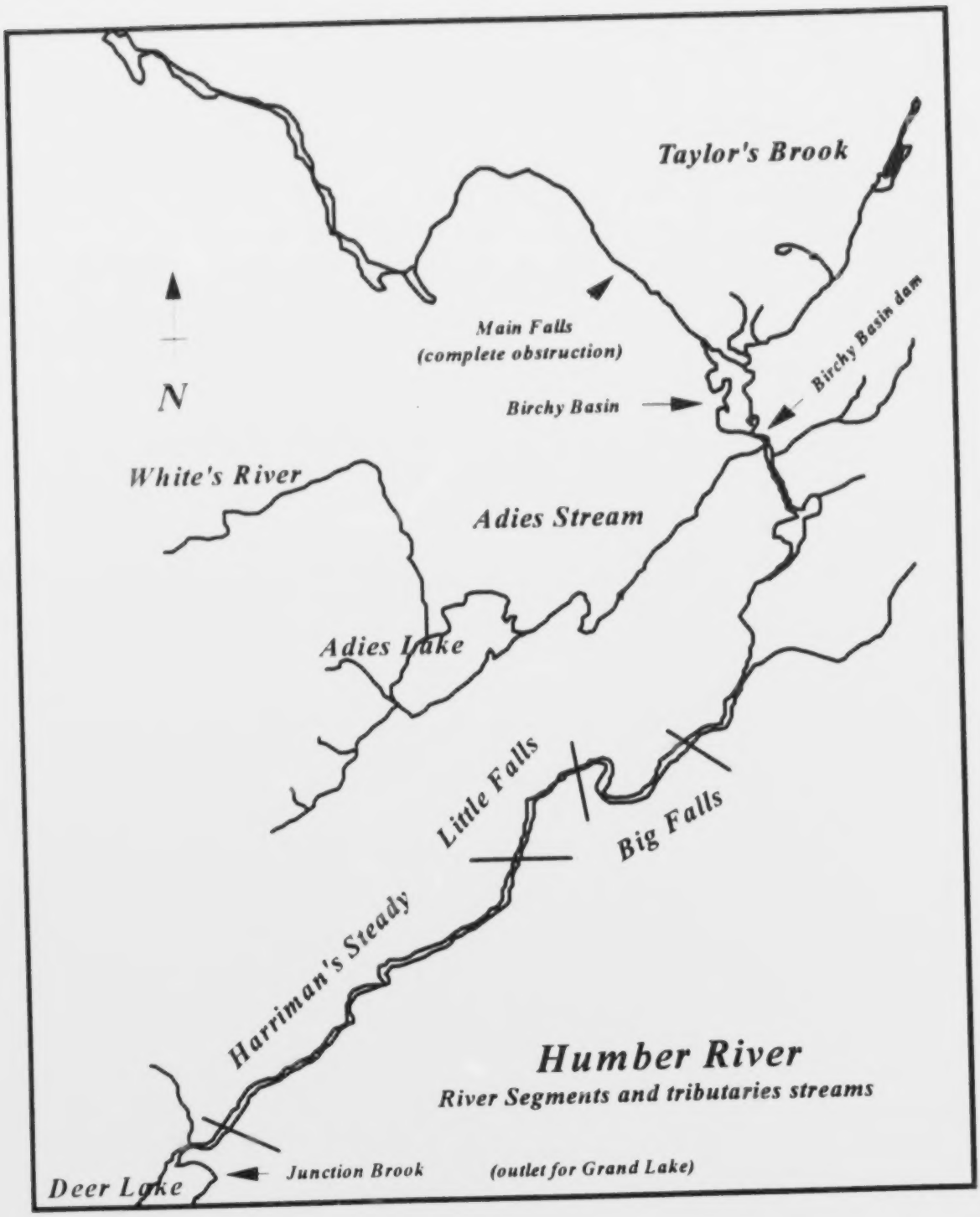


Figure 1 Location of two Atlantic salmon tagging traps operated on the Humber River in 1994.



igure 2 River segments of the Humber River, upstream of Deer Lake.

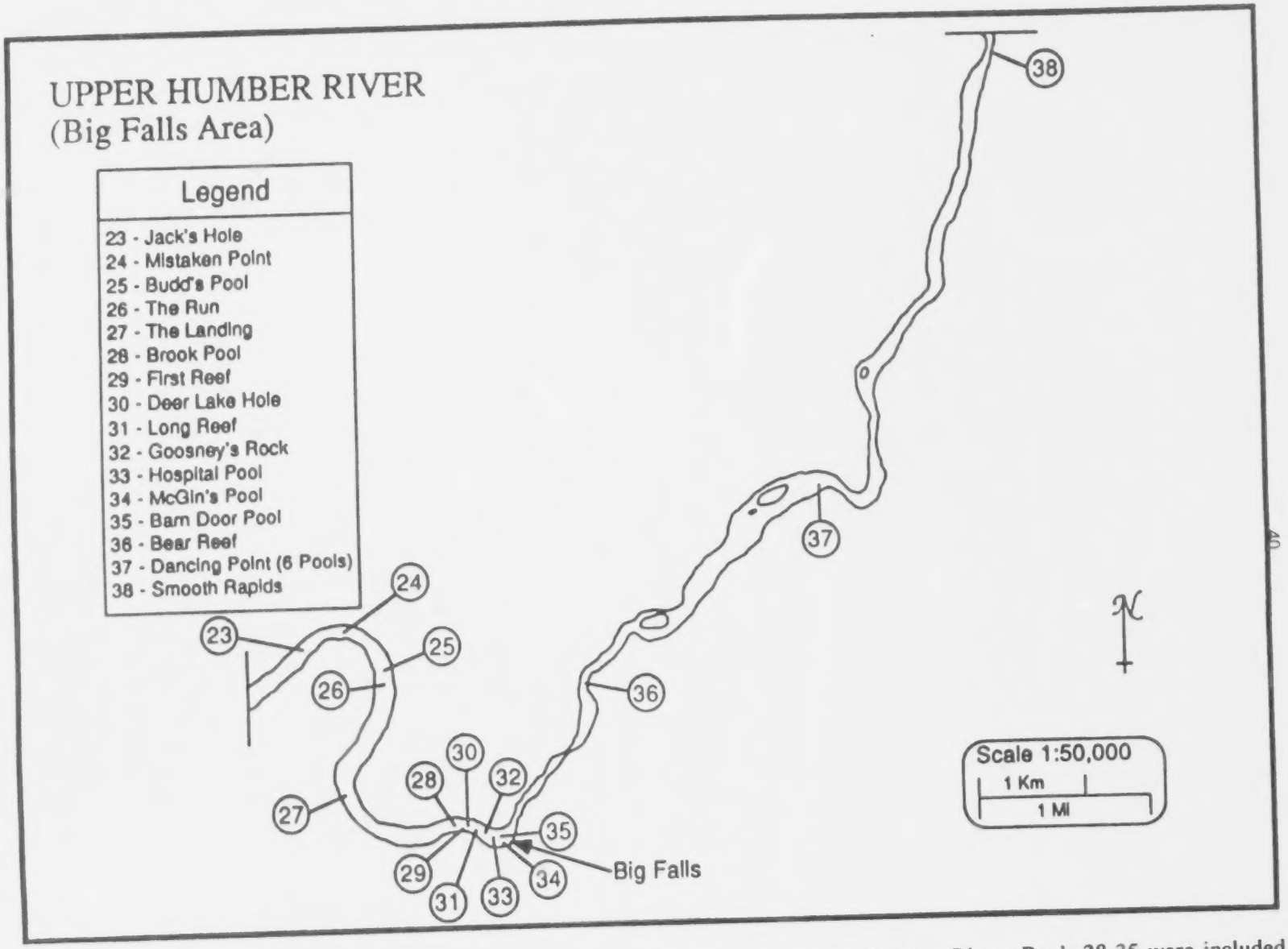


Figure 3. Location of the major salmon angling pools in the Big Falls area of the Humber River. Pools 28-35 were included in the creel survey, 1994 (from Hare, 1990).

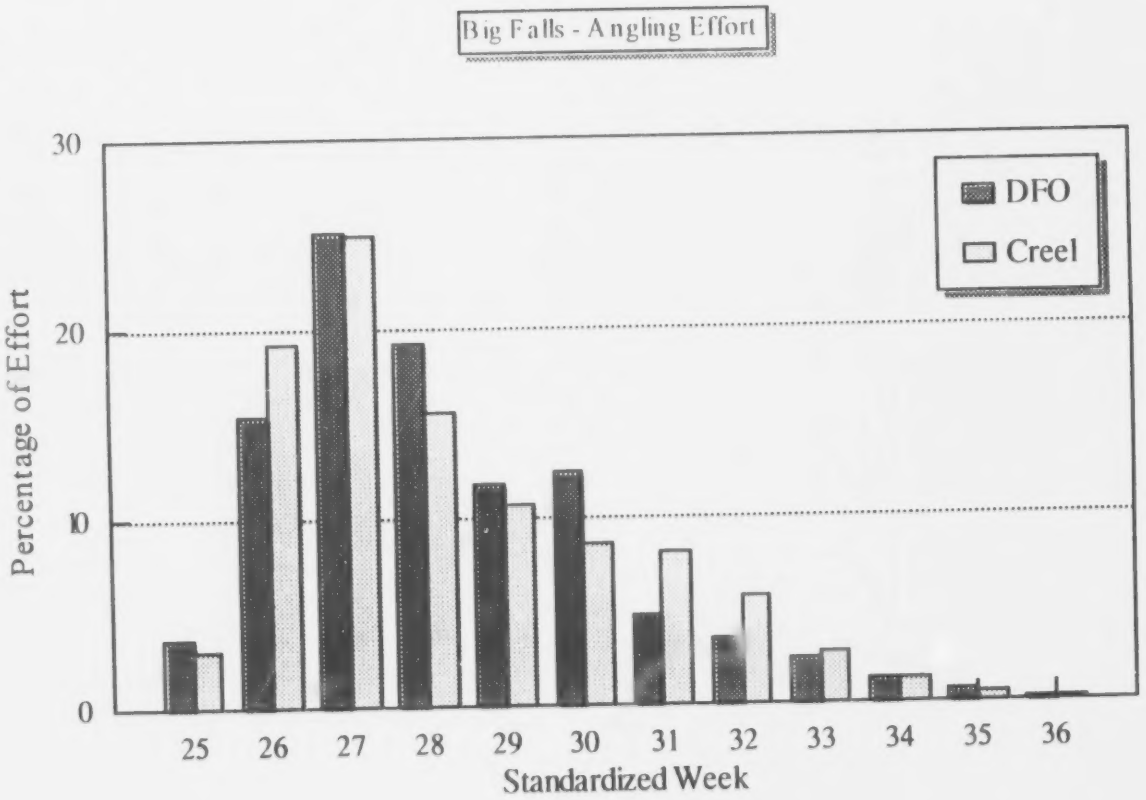


Figure 4. Comparison of weekly angling effort obtained by DFO and Creel methods.

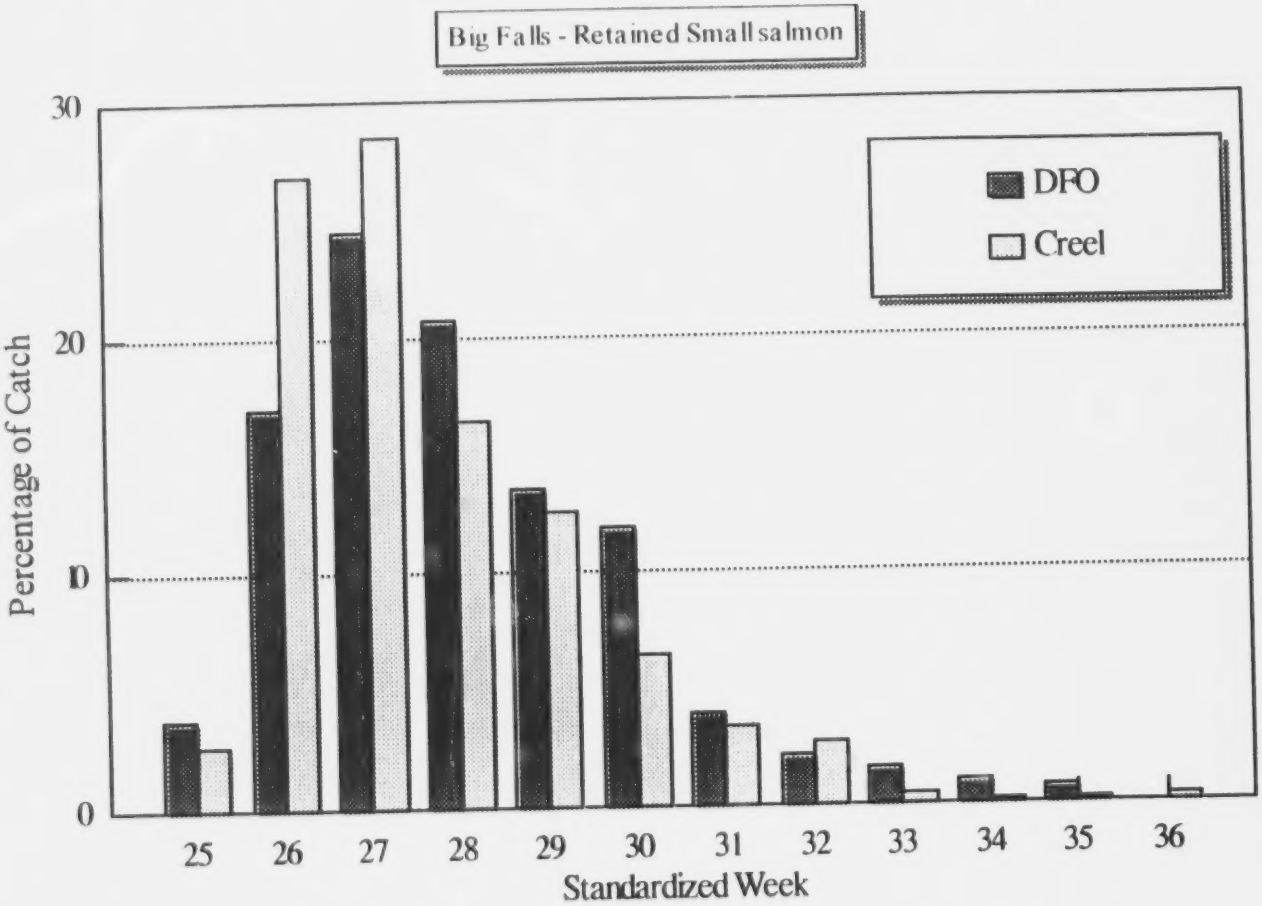


Figure 5. Retained catches of small salmon obtained from DFO and Creel methods.

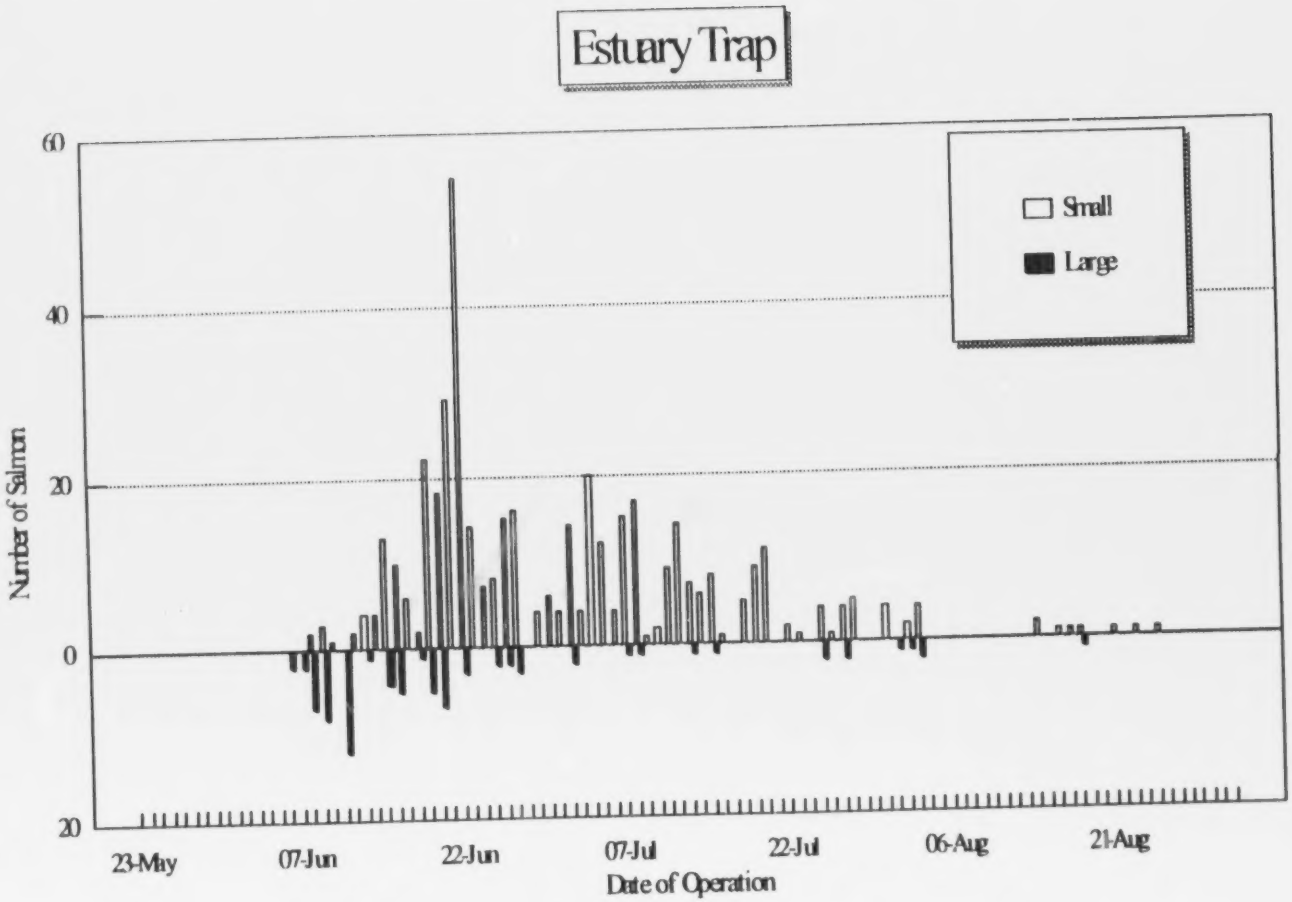


Figure 6a. Counts of small and large salmon at the Estuary tagging trap, 1994.

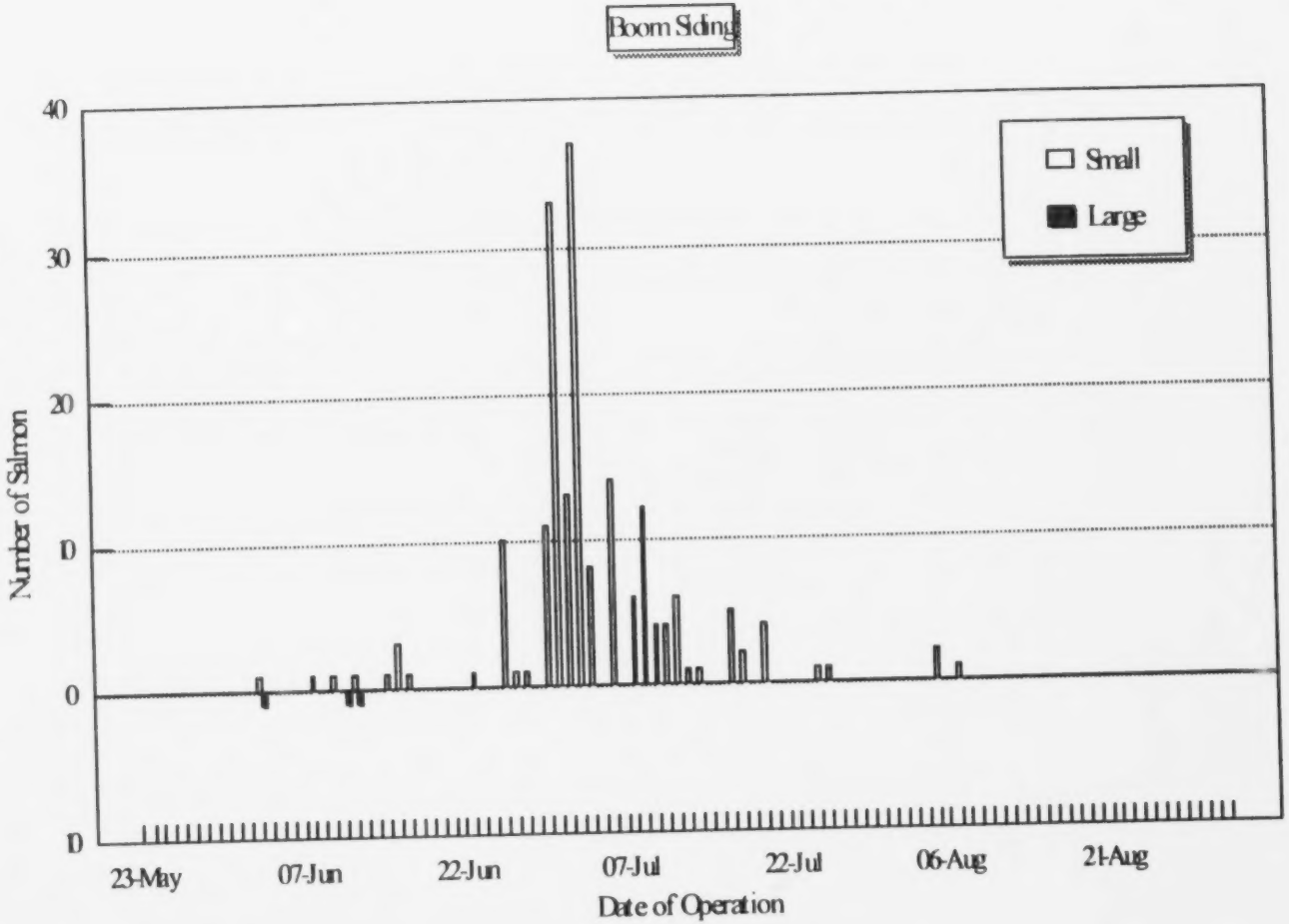


Figure 6b. Counts of small and large salmon at the Boom Siding tagging trap, 1994.

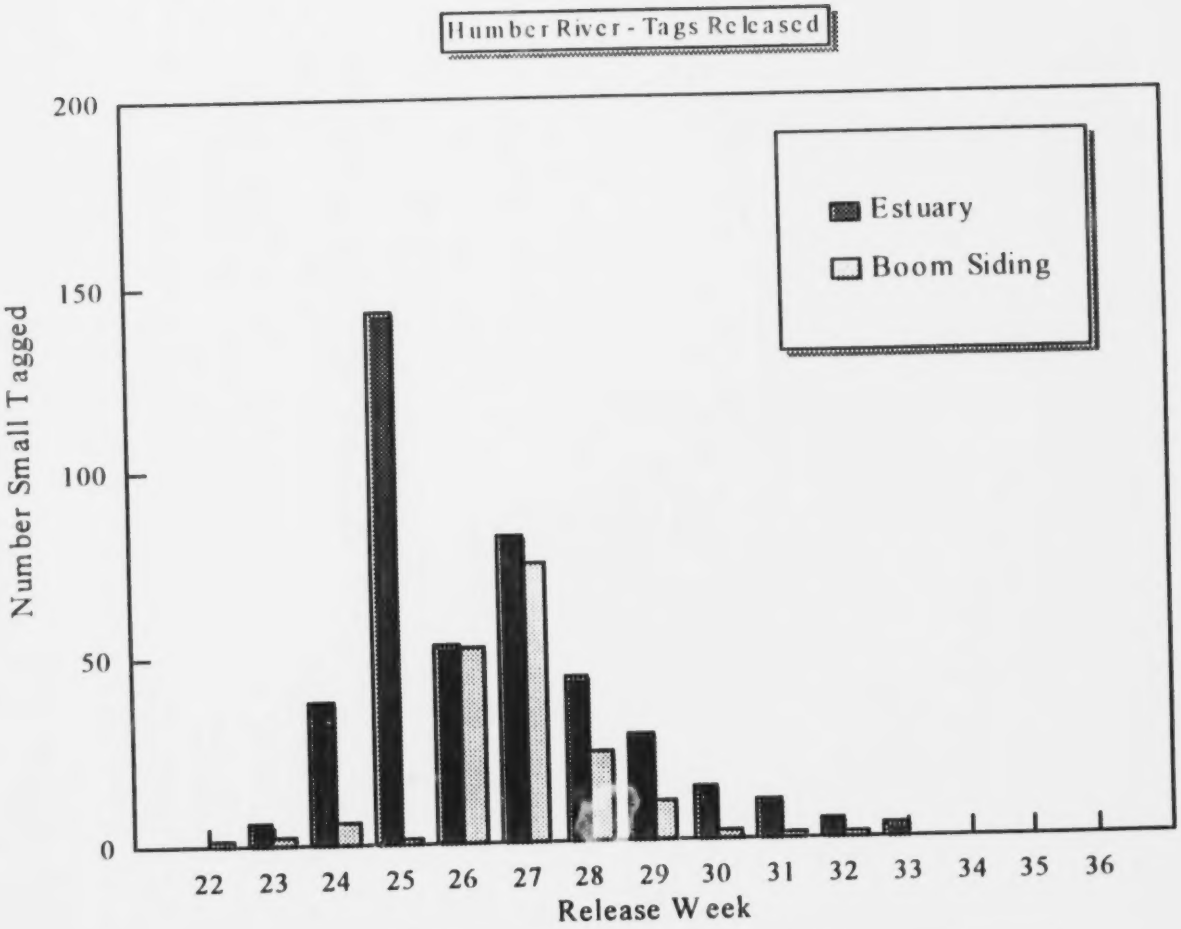


Figure 7. Timing of tags releases at the Estuary and Boom Siding tagging traps, 1994.

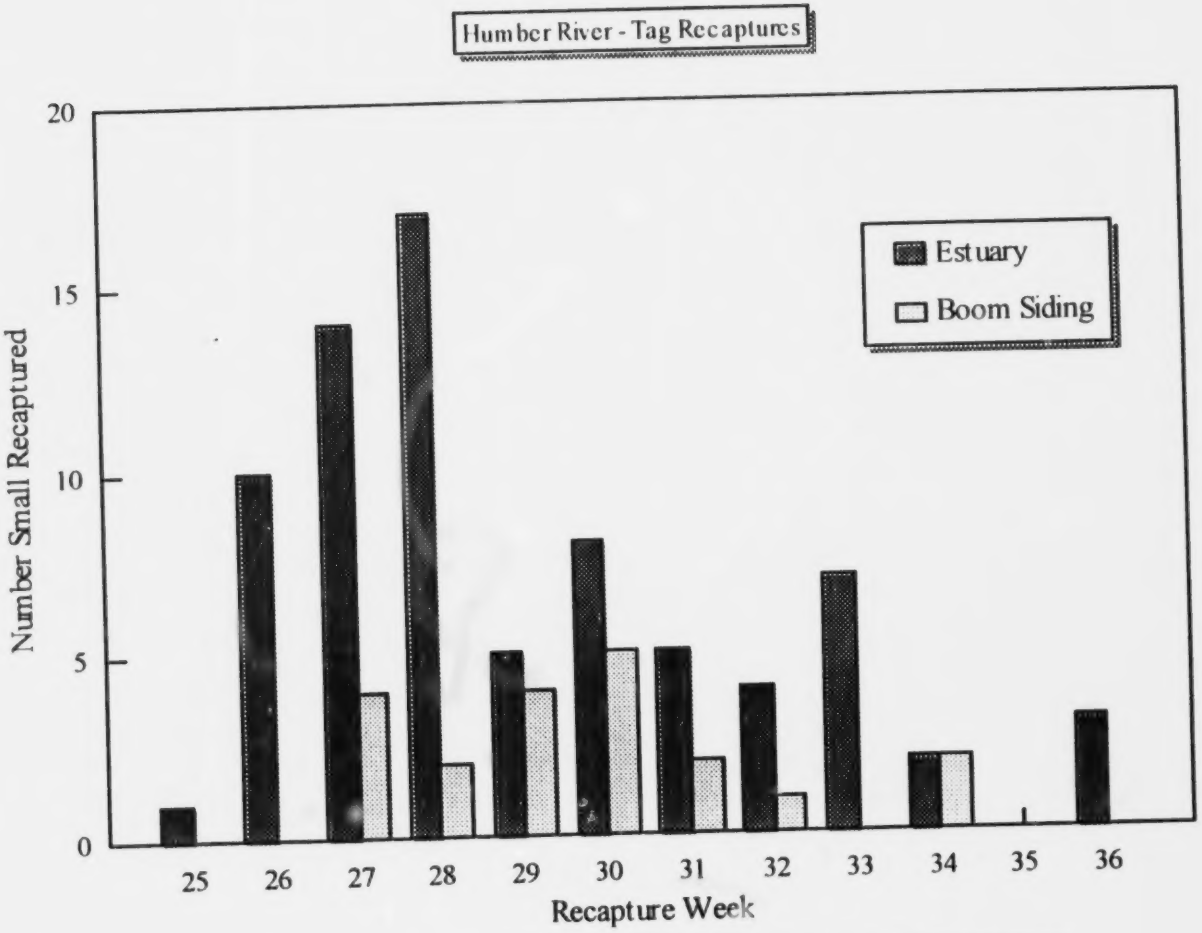


Figure 8. Timing of recaptures of small salmon tagged at the Estuary and Boom Siding traps, 1994.

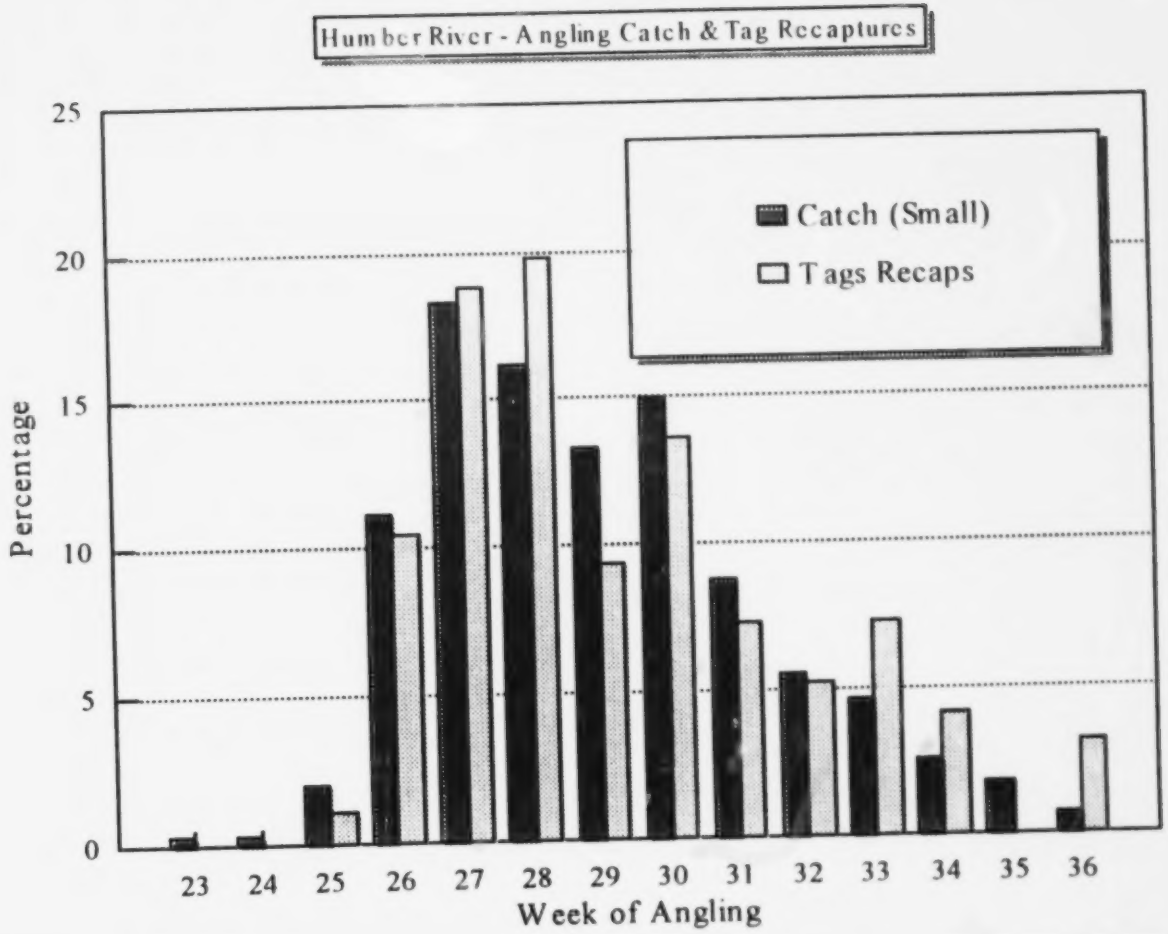


Figure 9. Comparison of timing of angling catches (DFO) and tag recaptures of small salmon, 1994.

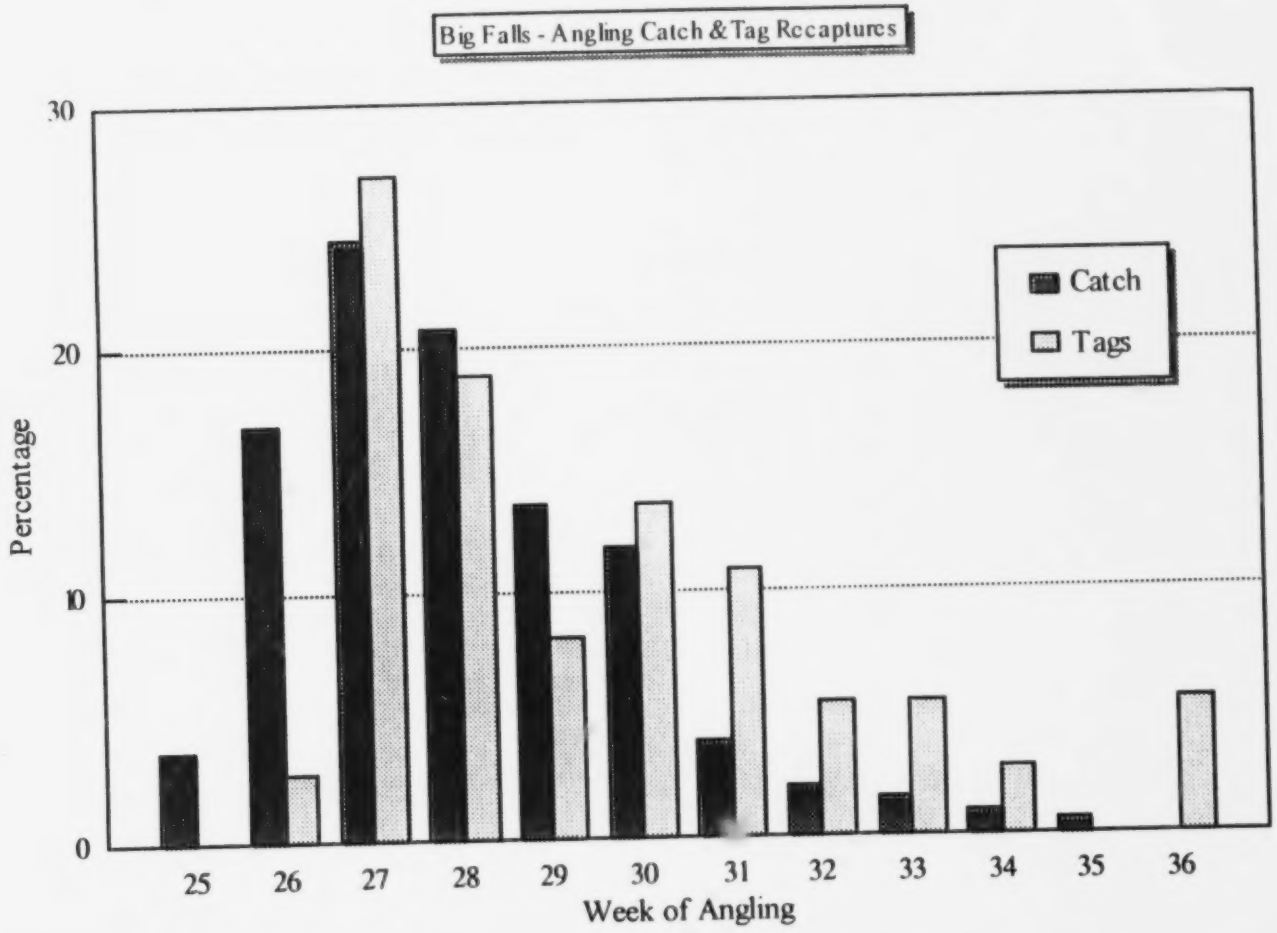


Figure 10. Timing of catches of small salmon retained and tag recaptures at Big Falls, 1994.

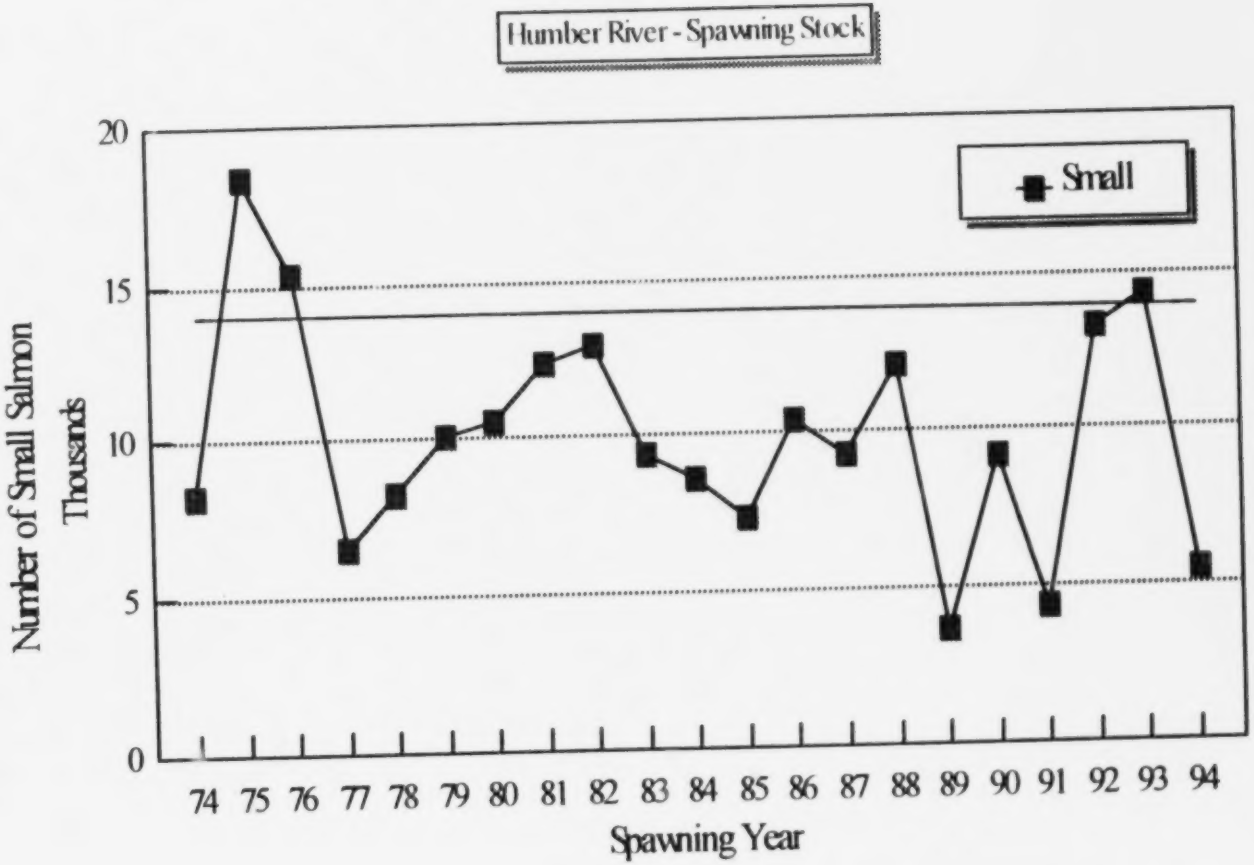


Figure 11 Potential spawning escapement of small salmon on the Humber River, 1974-1994. Solid horizontal line represents minimum spawning requirement for small salmon.

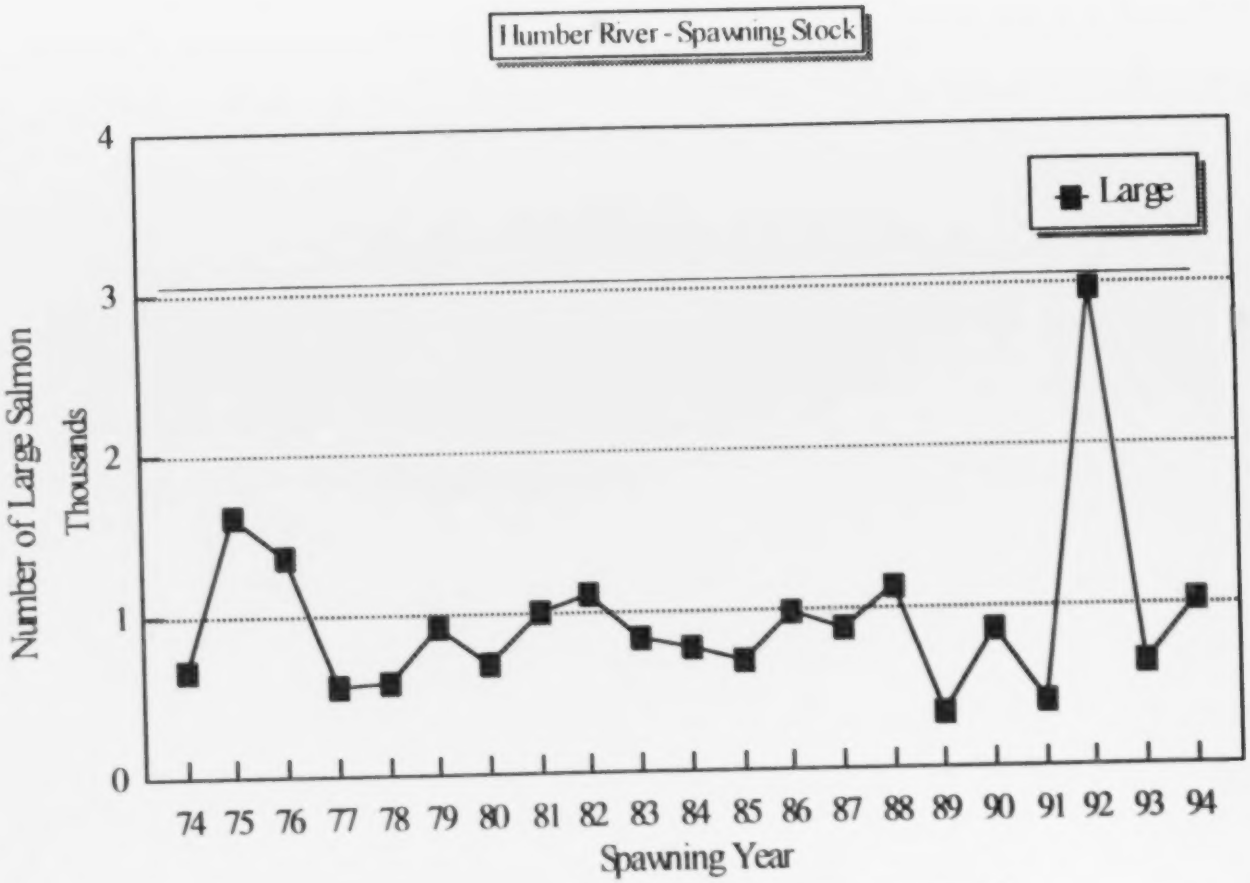


Figure 12. Potential spawning escapement of large salmon on the Humber River, 1974-1994. Solid horizontal line represents minimum spawning requirement for large salmon.

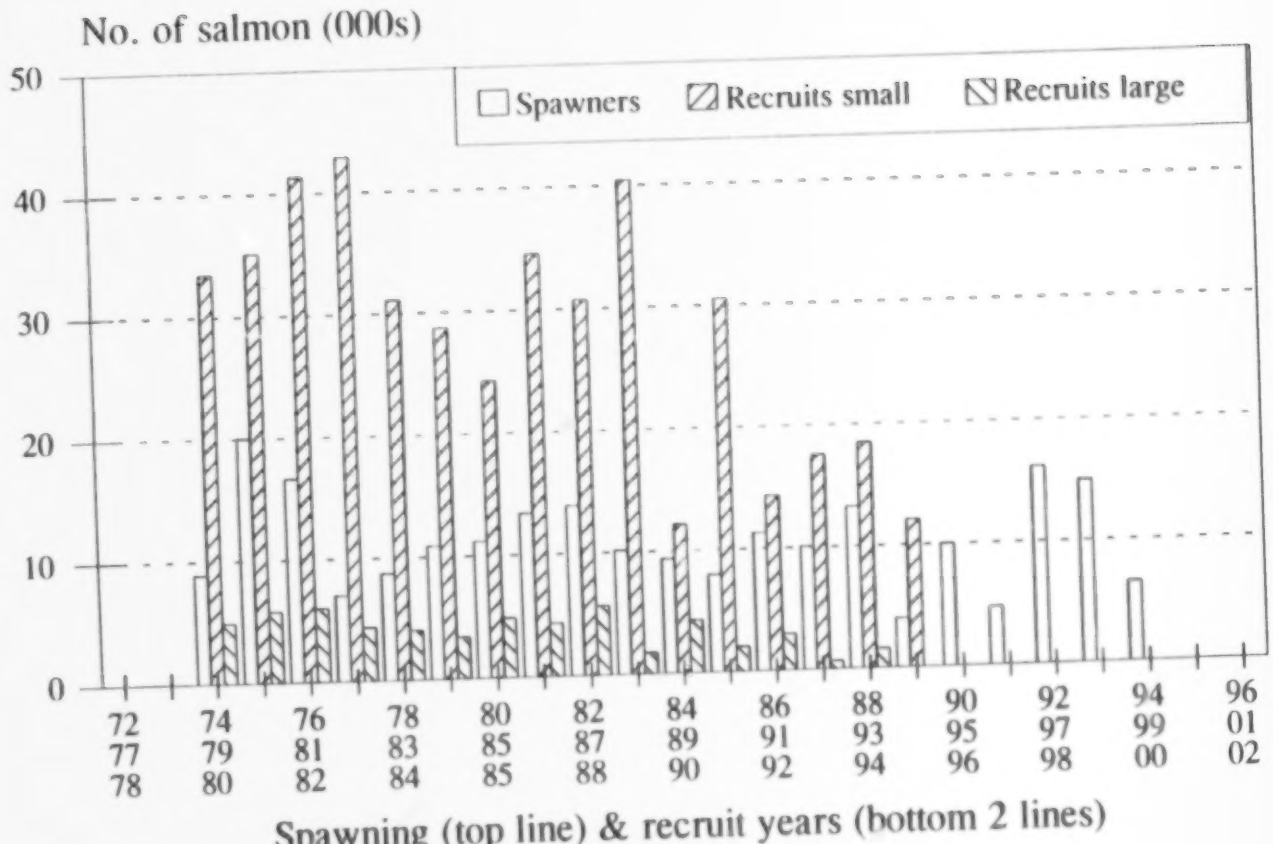


Figure 13. Spawners and corresponding recruits of small and large salmon on the Humber River, 1974-1994. Recruits are adjusted to spawning year-class.

Spawners in Humber River

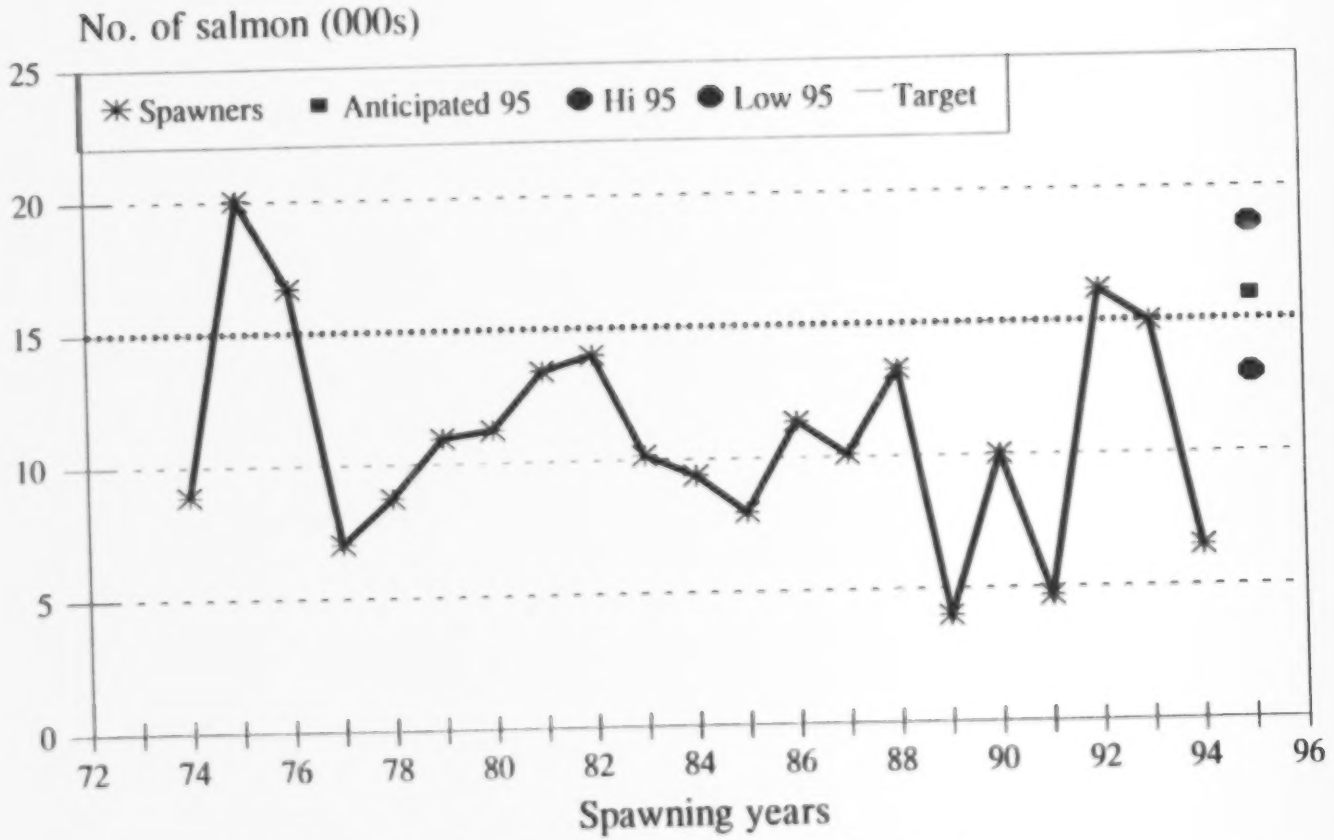


Figure 14. Spawning population of small and large salmon on the Humber River, 1974-1994 and anticipated spawners in 1995.

Number of small salmon produced per spawner for Humber River

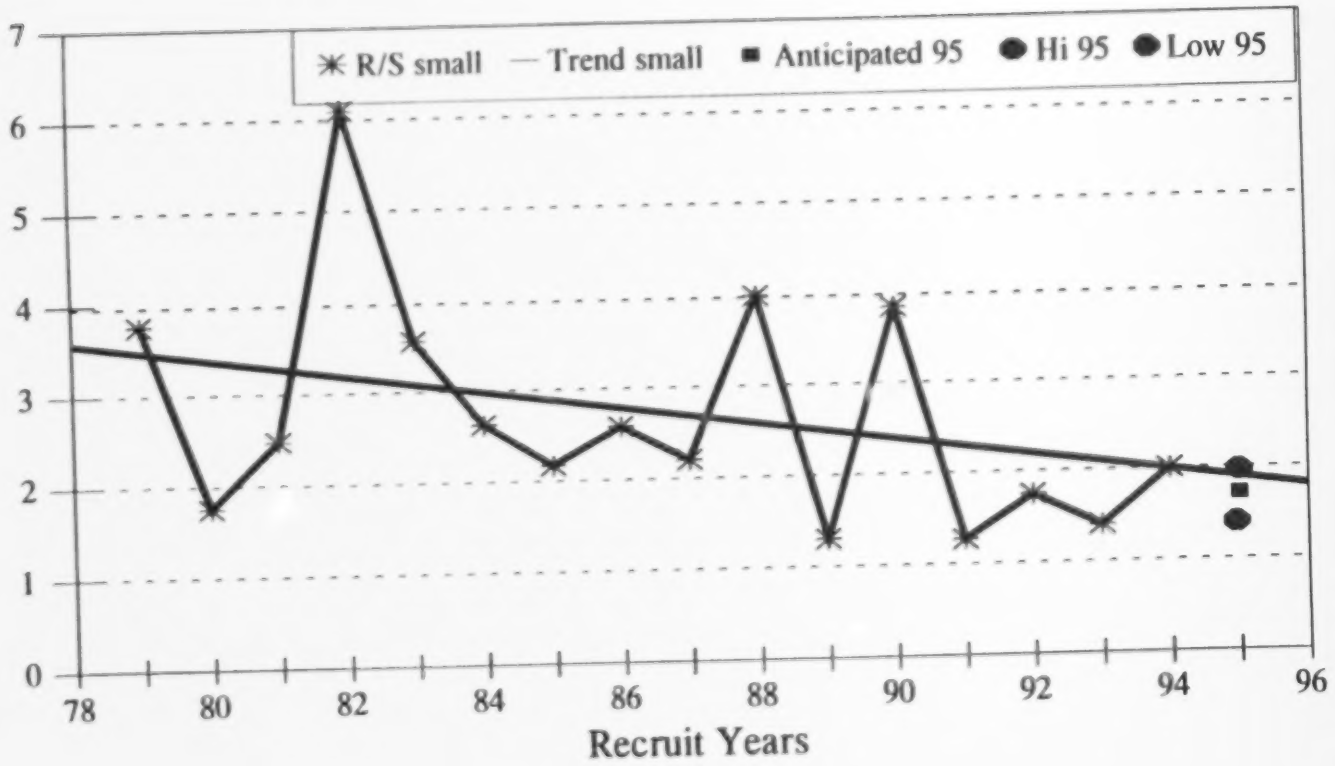


Figure 15. Ratio of small salmon recruits and spawners on the Humber River, 1978-1994 and anticipated ratio in 1995.

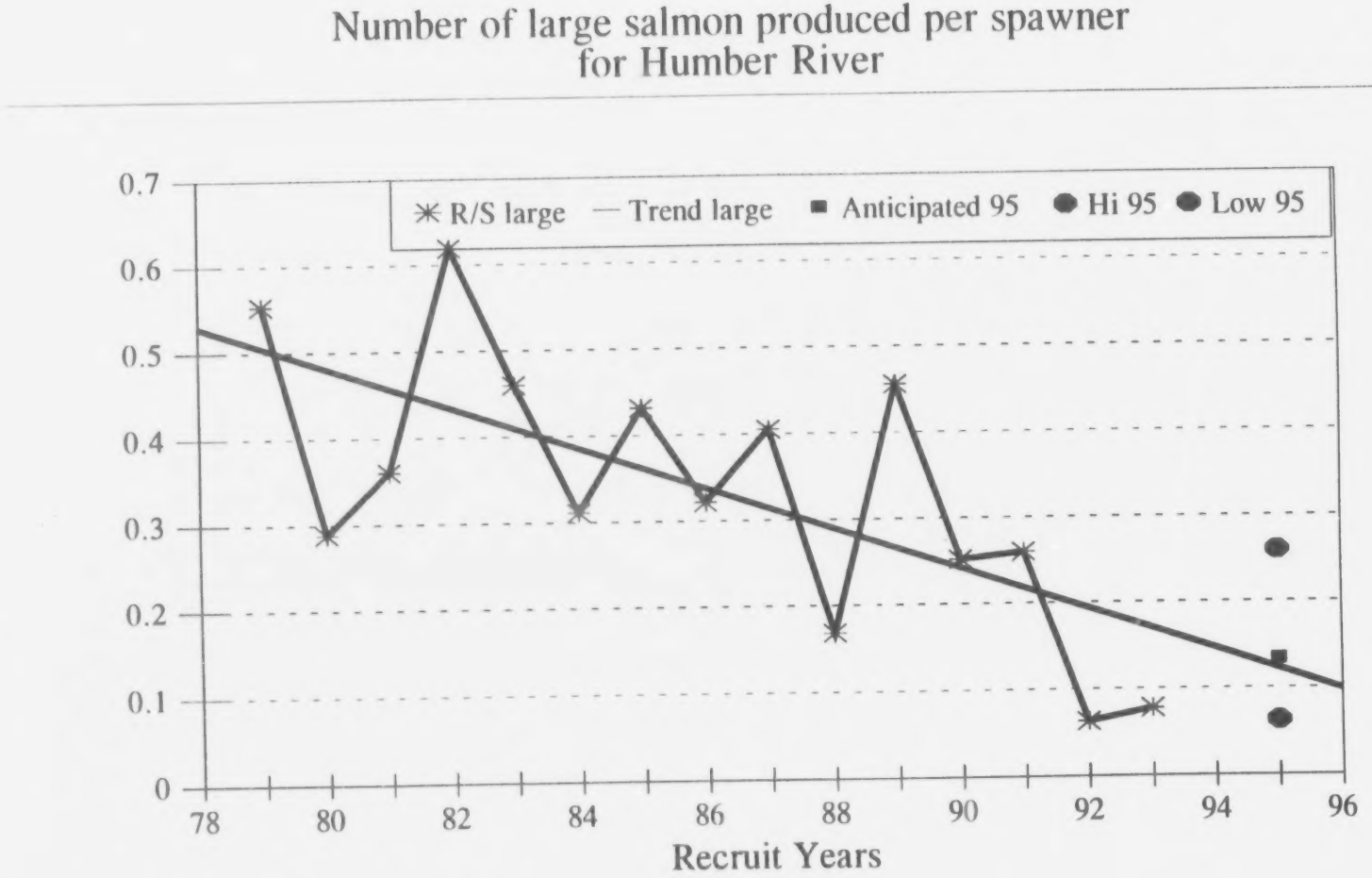


Figure 16. Ratio of large salmon recruits and spawners on the Humber River, 1978-1994 and anticipated ratio in 1995.

Total recruits for Humber River, Nfld

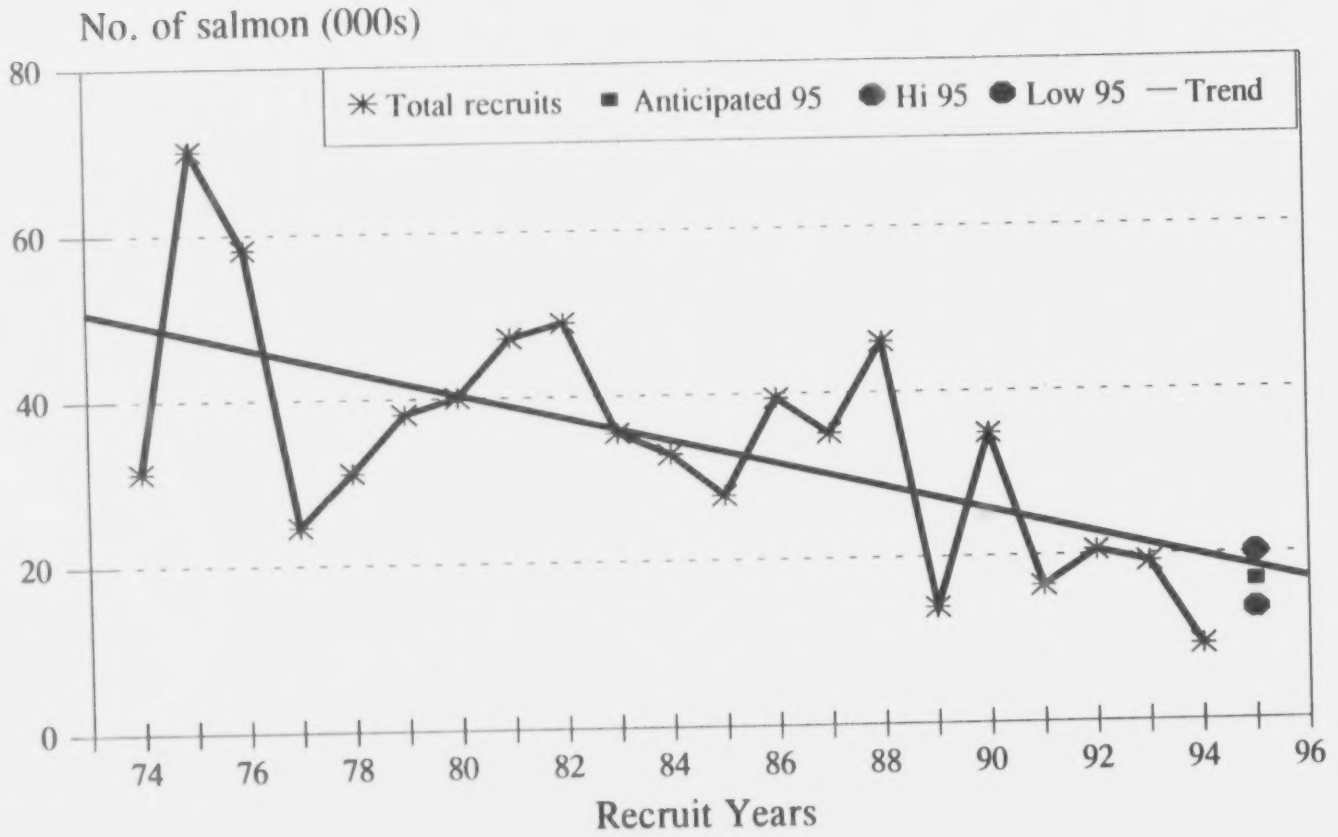


Figure 17. Total small and large salmon recruits on the Humber River, 1974-1994. and anticpated recruits in 1995.

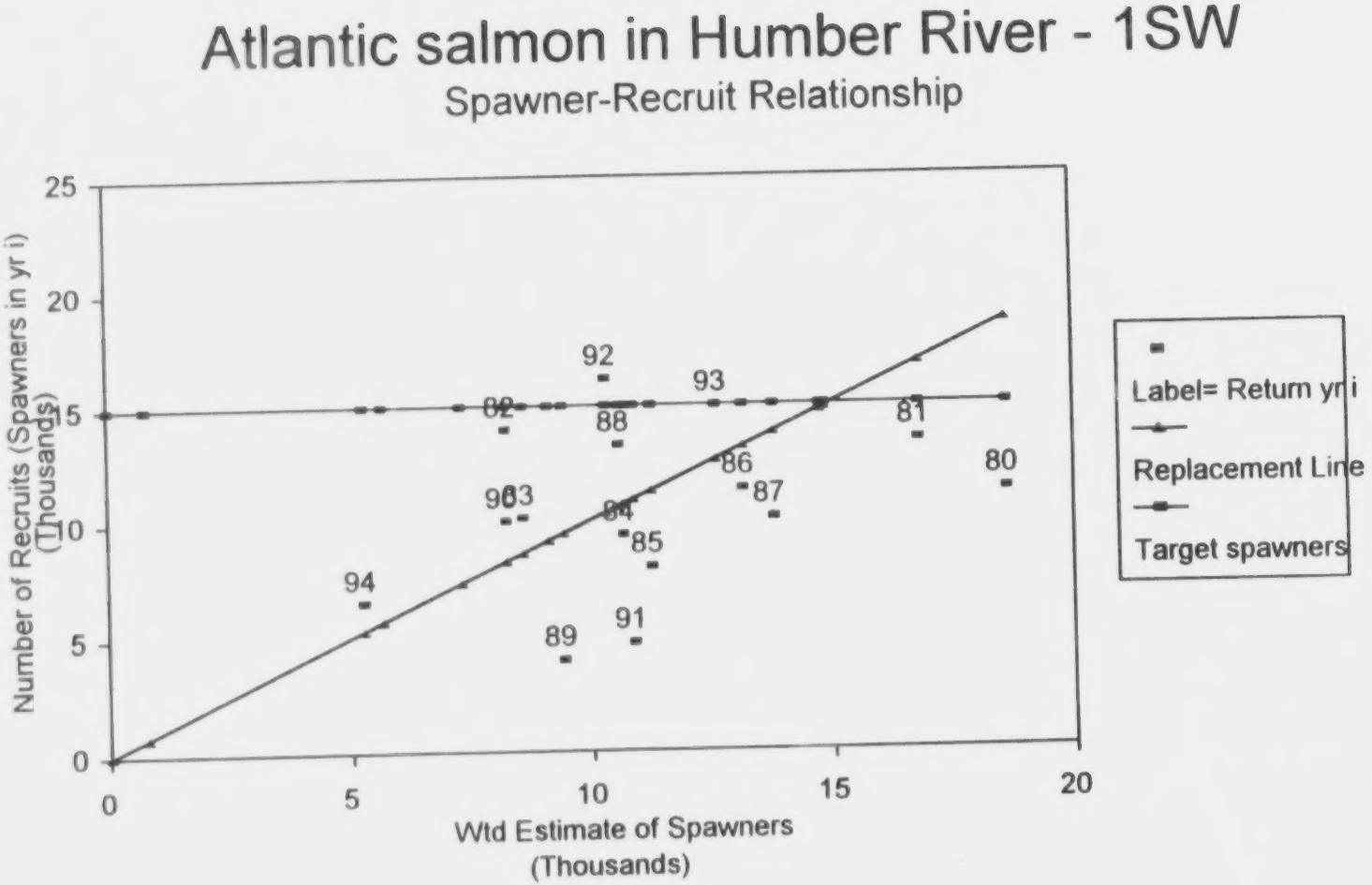


Figure 18. Relationship between 1SW Atlantic salmon spawners and recruits on the Humber River, 1980-1994.

Appendix 1. Initial data matrix for maximum-likelihood stratified estimate of small salmon returns to the Humber River, 1994.

"Humber River Estimate, 1994 (adjusted for recaptures in Lower Humber)"
No. of release strata (S) = 6
No. of recapture strata (T) = 6

		Adjusted Tag Returns					
		Recapture Strata (Weeks)					
Release Strata (Weeks)	Adj. Tags Avail.	25-26"	"27-28"	"29-30"	"31-32"	"33-34"	"35-36"
"22-23"	4	0	0	0	2	2	0
"24-25"	163	17	26	0	2	0	3
"26-27"	219	0	25	26	6	9	0
"28-29"	90	0	2	6	5	3	0
"30-31"	24	0	0	0	3	3	0
"32-34"	8	0	0	0	0	0	2
Catch of Small		330	843	628	262	126	39

Appendix 2. Collapsed data and maximum-likelihood estimate of returns.

```
1Humber River Estimate, 1994 (adjusted for recaptures in Lower Humber)

0Pooling in effect:

 ROW 1    = (22-23,24-25)
 ROW 2    = (26-27)
 ROW 3    = (28-29)
 ROW 4    = (30-31,32-34)
 COL 1    = (25-26,27-28)
 COL 2    = (29-30,31-32)
 COL 3    = (33-34,35-36)

 ----------
 Input Data
 ----------

S =  4 , T =  3

 The nc(i) vector is...

      ROW 1          ROW 2          ROW 3          ROW 4
       167.00         219.00          90.00          32.00

 The nr(j) vector is...

      COL 1          COL 2          COL 3
      1173.00         890.00         165.00

 The marks never seen again are...

      ROW 1          ROW 2          ROW 3          ROW 4
       115.00         153.00          74.00          24.00

 The u(j) vector is...

      COL 1          COL 2          COL 3
      1103.00         840.00         143.00

 The m(i,j) matrix is...

                    COL 1          COL 2          COL 3

      ROW 1          43.00           4.00           5.00

      ROW 2          25.00          32.00           9.00

      ROW 3           2.00          11.00           3.00

      ROW 4            .00           3.00           5.00
```

Appendix 2. (continued)

```
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Output Data
-----------

The E[m(i,j)] matrix is...

                COL 1          COL 2          COL 3

    ROW 1         44.31           4.20           5.27

    ROW 2         23.45          28.90           8.09

    ROW 3          2.46          15.83           4.42

    ROW 4           .00           2.89           4.81

The estimated stratification at recapture time...

     COL 1          COL 2          COL 3
   3380.89        3613.20         695.68

The probability of recapture estimates...

     COL 1          COL 2          COL 3
     .3469          .2463          .2372

Log likelihood =      1629.11
Estimated population size (std. err.) =      7700.26  (      747.61)
G2 goodness of fit =     3.739535    X2 goodness of fit =     3.526996

                          ---------- End of run ----------
```